OL. XXXIII. — No. 12. DECEMBER 1956.

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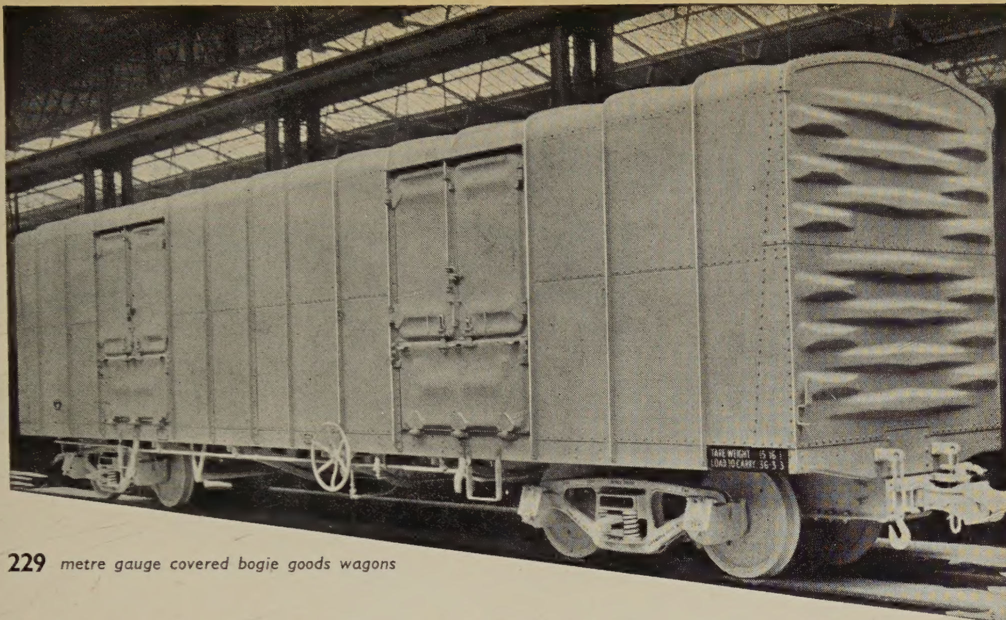
(English Edition)



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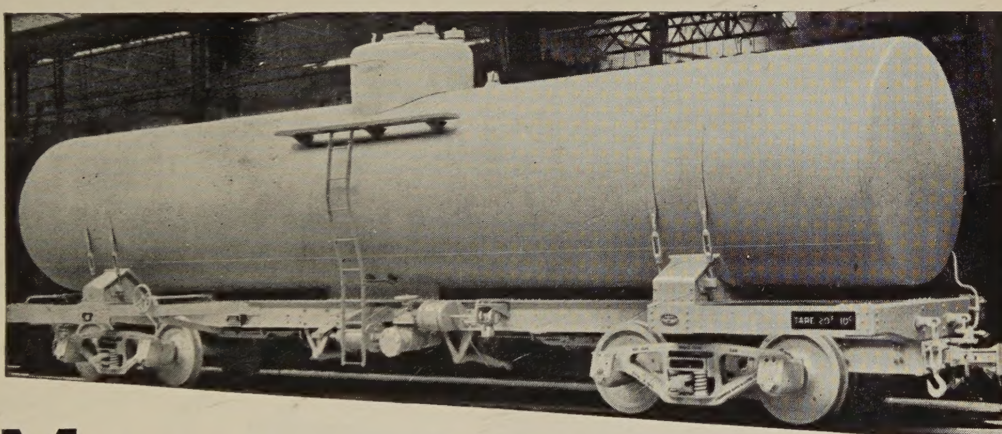

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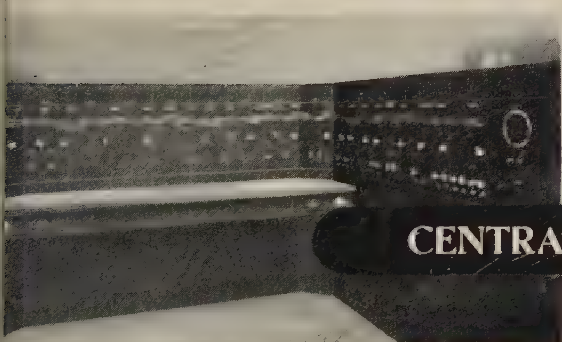

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MONTHLY BULLETIN

OF THE

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(ENGLISH EDITION)

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CONTENTS OF THE NUMBER FOR DECEMBER 1956.

CONTENTS *(continued)*.		Page.
X.	**Comparative merits of C.T.C. and doubling**, by L.C. MOHINDRA	1050
XI.	NEW BOOKS AND PUBLICATIONS : **Directory of Railway Officials and Year Book, 1956-1957**	1055
XII.	**1st. International Congress of Funicular Transport**	1056
XIII.	MONTHLY BIBLIOGRAPHY OF RAILWAYS	91
XIV.	ANALYTICAL TABLE OF ARTICLES ACCORDING TO THE DECIMAL CLASSIFICATION . . .	1 to 8
XV.	CONTENTS OF THE 33RD YEAR OF THE ENGLISH EDITION	I to VIII

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BULLETIN
OF THE
INTERNATIONAL RAILWAY CONGRESS
ASSOCIATION
(ENGLISH EDITION)

[625 .212 (493)]

First results of the intensive utilisation of ultrasonics for the detection of axle flaws,

by E. MEYER,

Ingénieur principal au Service du Matériel et des Achats de la Société Nationale des Chemins de fer belges.

Introduction

In a preceding article which appeared in the December, 1955, issue of this *Bulletin*, we explained the working principle on which the detection of axle flaws by the ultrasonics method is based, as well as the first results obtained with a testing apparatus.

Experience with this apparatus was so satisfactory that it was decided to acquire three sets which were supplied in December, 1955.

In the present article, it is proposed to deal with the results obtained. These confirm the facts which prompted the acquisition of the sets.

The sets are worked by operators who have undergone a training of four weeks. These men were not selected because of their technical qualification. They were workmen with different qualifications known for their intelligence, their power of observation and their independent judgment.

These three qualities are regarded as more important than a packet of scientific qualifications.

Training of operators

The training of the operators consisted of two parts :

(*a*) a greatly simplified theoretical explanation of the working of the apparatus, the notion of waves, and the reflection of the waves;

(*b*) the operation of the apparatus, and a critical review of the readings.

For this purpose, the operators were shown test pieces with flaws which they had found, and with flaws which they had not detected. These test pieces were taken from the axles inspected.

An instructor asked them to test these pieces, and checked their observations. This training is mainly intended for operators called upon to work the sets immediately. The working method is explained in the Appendix.

General organisation of the flaw detection work.

The three sets acquired have been allocated as follows :

(*a*) one set to Cuesmes Central Workshop;

(*b*) one set to Gentbrugge Central Workshop;

(*c*) one set to Schaerbeek Wagon Workshop.

The instructor is stationed at Cuesmes. Those axles which the operators at the other workshops regard as defective are sent to Cuesmes Central Workshop and subjected to a second check.

It may be stated at once that this check is very satisfactory. The two operators find the same indications.

The axles are then magnetically tested and are either returned to service or definitively scrapped, according to the result of the magnetic test.

A number of scrapped axles were broken into pieces in order to measure the depth of the fractures and to check the sensitivity of the method as well as the quality of the operators.

The numbers of axles dealt with are summarized in the table below.

Summary of axle tests.

Total number of axle seats inspected : 759	Number of axle seats passed as sound by the ultrasonics operator : 476.	381 passed as sound by the operator working the magnetic testing apparatus.
		95 declared cracked by the operator working the magnetic testing apparatus.
	Number of axle seats declared cracked by the ultrasonics operator : 283	102 passed as sound
		181 declared cracked

In addition, 76 of the 181 axle seats which were cracked and declared as such by the ultrasonics operators, and 61 of the 95 axle seats which were cracked but not detected as such by the same operators were broken into pieces in order to measure the depth of the cracks.

The following table shows, for each of these categories of axles, the number of axle seats cracked, according to the depth of the crack.

Depth of crack in millimetres	*Number of cracked axle seats detected by the ultrasonics apparatus*	*Number of cracked axle seats not detected by the ultrasonics apparatus*
0 to 1 mm	8	11
1 to 2 mm	26	35
2 to 3 mm	18	11
3 to 4 mm	3	4
4 to 5 mm	6	
5 to 6 mm	5	
6 to 7 mm	3	
7 to 8 mm	3	
8 to 9 mm	1	
9 to 10 mm	0	
10 to 11 mm	1	
17 to 18 mm	1	
18 to 19 mm	1	
Totals :	76	61

One first remark comes to mind immediately : All the important cracks, i.e. all those deeper than 4 mm, have been detected by the operator.

It can be assumed that flaws of smaller depth are not very dangerous since axles with cracks as deep as 5 mm, 10 to 17 and 18 mm were still in service.

It is reasonable to assume that the size of a flaw increases but slowly. If it were otherwise, the number of axles

fractured in operation would be high, which is not the case.

If, from a theoretical point of view, it may be regrettable that the operator has not detected all flaws without exception, it must nevertheless be recognised that he has been able to cause the withdrawal from service of the most dangerous axles, and that the others will be detected on the occasion of the next inspection, i.e. when the crack has become greater which will only be the case after a fairly long time.

Savings effected by the ultrasonics apparatus.

It is of interest to compare the cost of the inspection of 1 000 axles by the magnetic method, and by the two methods combined.

As it is necessary, because of the indispensable machinery (e.g. the presses required for the removal and re-mounting of the wheels) to concentrate the inspection by the magnetic method in a single central workshop, the axles must be transported from the lineside depots to the central workshop. The expenses thereby incurred include, per axle :

(*a*) Cost of loading and unloading	32 Francs
(*b*) Cost of transport (round-trip of 150 km)	11 Francs
(*c*) Cost of maintaining the rolling stock used for this purpose	4 Francs
(*d*) Partial dismantling, cleaning and inspection of the axle seats. (*e*) Re-assembling the axles	60 Francs
Total cost per axle	107 Francs

Cost for 1 000 axles : 107 000 Francs.

If the ultrasonics method is used, it must be assumed that $\frac{476}{759}$ of the wheel seats will be declared as sound, corresponding to 1 254 wheel seats out of 2 000 inspected, whilst 746 remain doubtful. But it cannot be deduced that 627 axles will be declared as sound, as it is not certain that the two wheel seats of the same axle will both be sound. However as the age and stresses will be identical, it may be assumed that the number of entirely sound axles will be around 500.

The expenses to be incurred thus amount to :

(*a*) Cost of the ultrasonic inspection of 1 000 axles :

cost per axle	25 Francs
cost per 1 000 axles.	25 000 Francs

(*b*) Cost of magnetic inspection of 500 axles. 53 500 Francs

The costs of the combined method thus amount, for 1 000 axles, to :

$$25\,000 + 53\,500 = 78\,500 \text{ Francs.}$$

The savings resulting from the application of the method thus amount to :

$$107\,000 - 78\,500 = 28\,500 \text{ Francs.}$$

The saving per axle is 28.50 Francs.

Having regard to the fact that some 30 000 axles are urgently in need of inspection, the savings effected amount to :

$$30\,500 \times 28.5 = 855\,000 \text{ Francs.}$$

This advantage has been obtained by the acquisition of three sets costing less than 100 000 Francs each.

No account has been taken of the fact that, through the application of the ultrasonics method, the time originally

anticipated for withdrawing the dangerous axles from service will be reduced and the risk of accidents thereby lessened.

APPENDIX

It is thought to be of interest to publish here the provisional instructions which have been worked out for the operators entrusted with the inspection of axles.

These instructions which lay down the procedure to be followed by the operator have been compiled in collaboration with Dr. KRAUTKRÄMER who has been good enough to allow us to make full use of the booklet which he has published. The author wishes to take this opportunity to express his deep gratitude to Dr. KRAUTKRÄMER for his so effective cooperation on the occasion of the tests which were carried out jointly.

PROVISIONAL INSTRUCTIONS

1. Preparation of the axles.

(*a*) *Cleaning.*

All traces of rust or paint must be removed from the axles on a zone of 20 cm, reckoned from the inner edge of the wheel seat, so as to obtain a good contact surface between pulsator and axle. A steel brush operated by a motor is used for this purpose.

(*b*) *Transmitting agent.*

The axle zones thus cleaned must be covered with a thick coat of suitable oil.

2. Preparation of the apparatus.

(*a*) *Adjustment of apparatus.*

The ultrasonics apparatus must be taken into operation by using a field depth of 250 mm.

(*b*) *Pulsator.*

The pulsator is shown in figure 1. It is of the oblique type where the main beam enters the steel at an angle of 37°. The plexiglass wedge has two red markings on the sides, parallel to the main beam.

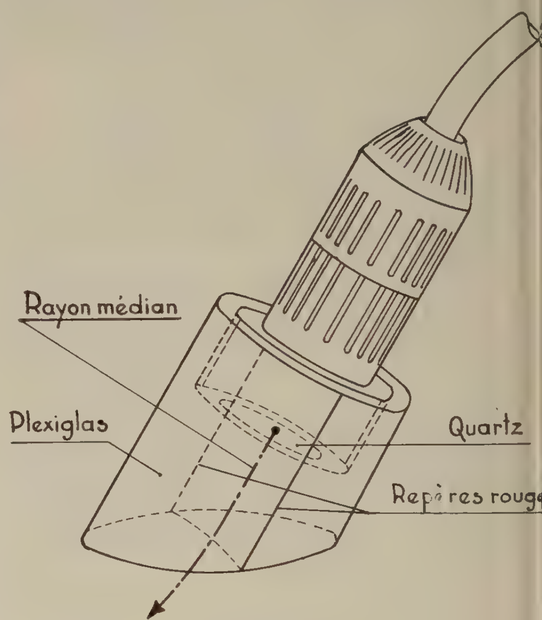


Fig. 1.
Rayon médian = central beam.
Repères rouges = red marks.

3. Preliminary calculations.

(A) PRELIMINARY CALCULATION OF THE DISTANCE *a* OF THE PULSATOR.

Before beginning the examination, it is necessary to estimate the most favourable position of the pulsator in relation to the section or zone where cracks are suspected.

The most favourable position of the pulsator is the one in which the central beam touches the point where the crack has originated (fig. 2). The task of the operators will be facilitated by the use of appropriate templates.

(*a*) *Constant diameter.*

If crack and pulsator are situated on circles of the same diameter D, the most favourable position of the pulsator a is equal to 3/4 of diameter D, i.e. :

$$a = \frac{3}{4} D$$

a may be calculated from the above formula, but it may also be read off from the diagram in which this equation is shown graphically (fig. 3).

Example :

An axle with a wheel seat diameter not greater than that of the shaft is to be examined in the vicinity of the inner edge of the wheel seat.

Diameter D is 155 mm.

The most favourable distance a is than calculated as follows :

$$a = \frac{3}{4} D = 116 \text{ mm.}$$

(*b*) *Different diameters.*

If flaw and pulsator are situated on sections of the axle which have different diameters D_1 and D_2, instead of D, it is necessary to take the mean value

$$D_M = 1/2 \ (D_1 + D_2).$$

so that

$$a = \frac{3}{4} D_M$$

Example :

An axle with wheel seat of greater diameter is to be examined at the wheel seat. The diameter of the latter is $D_1 = 200$ mm, that of the shaft $D_2 = 160$ mm.

The mean value of the diameter works out at :

$$D_M = 1/2 \ (200 + 160) = 180 \text{ mm.}$$

and the distance :

$$a = \frac{3}{4} 180 = 135 \text{ mm.}$$

(*c*) *Prior calculation of the position of the defect.*

In order to determine the zone of the screen where the greatest echo must be expected, it is first necessary to calculate the complete distance L covered by the wave. This distance consists of the path through the plexiglass :

$$L_{PL} = 25 \text{ mm}$$

and of the path through the steel, L_a, which amounts to 5/4 times the diameter D so that the total distance is

$$L = 25 + \frac{5}{4} D$$

On the basis of the total distance L, it is possible to calculate the marker line in the vicinity of which the echo will appear if the axle is cracked :

$$T = \frac{2.L}{100} - 1$$

where T is the number of the mark on the screen. L must be expressed in millimetres.

Example :

Constant diameter.

One is looking for a flaw in the wheel seat of an axle of 155 mm constant

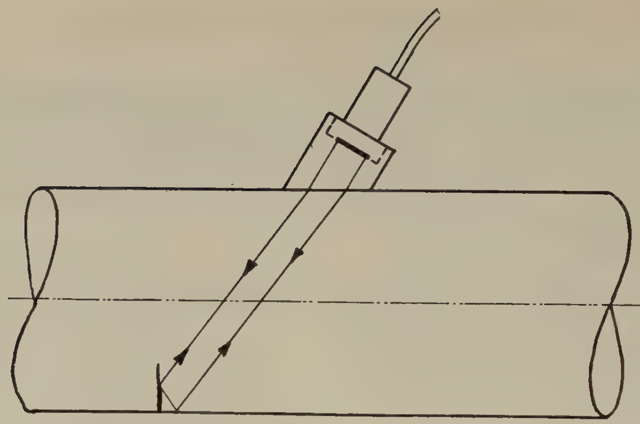


Fig. 2.

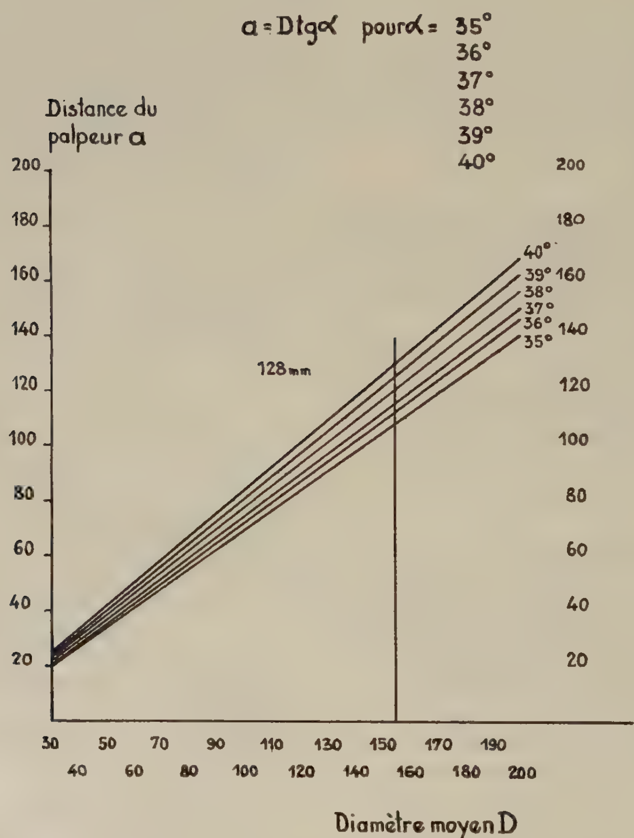


Fig. 3.

Distance du palpeur = distance of pulsator. — Diamètre moyen = mean diameter : a = D tan α for α = 35°...

diameter. Where can one expect the echo due to a defect?

$$L = 25 + 155 \times \frac{5}{4} = 219 \text{ mm}$$

$$T = \frac{2 \times 219}{100} - 1$$

$$T = 3.4$$

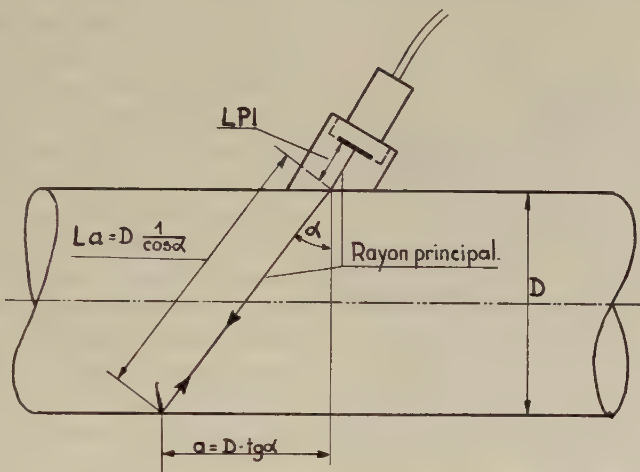


Fig. 4.
Rayon principal = mean beam.

The signal will therefore be located between marks 3 and 4, a little in front of the halfway point between these marks.

Different diameters.

If flaw and pulsator are located on sections with different diameters D_1 and D_2, D must be replaced by the mean value :

$$D_M = \frac{1}{2} (D_1 + D_2)$$

$$L = 25 + \frac{5}{4} D_M$$

Example :

An axle with wheel seat diameter greater than that of the axle, $D_1 = 200$ mm, $D_2 = 160$ mm, is to be examined for a crack in the wheel seat. The distance covered by the wave is :

$$L = 25 + 180 \times \frac{5}{4} = 250 \text{ mm}$$

It follows that the echo will be received in the vicinity of line 4.

3. Procedure to be followed by the operator.

(*a*) *Principle.*

The pulsator must be placed in such a way that the distance from the inner edge of the wheel seat to the red mark amounts to *a*.

Because of the curvature of the supporting surface, the distance is actually slightly smaller than *a* (by about 1-2 mm) but this can be neglected. With the distance *a* as mean value, the pulsator must be applied to the axle by describing a sinusoidal line so that the amplitude in the direction of the axle is at least 3 cm and the wave length at most 3 cm (fig. 5).

As the pulsator is moved, the screen must be continuously observed. From time to time, the pulsator itself must be observed so as to make sure that there is contact between pulsator and axle which can be ascertained from the silvery noise made by the pulsator. If necessary, the contact must be improved by applying the liquid.

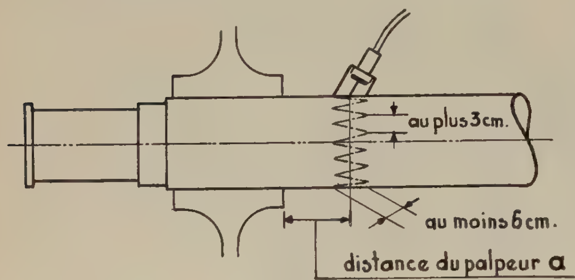


Fig. 5.

Distance du palpeur = distance of pulsator : au plus 3 cm = maximum 3 cm; au moins 6 cm = minimum 6 cm.

(B) HANDLING THE PULSATOR IF FRACTURES ARE INDICATED.

If echos are observed during the zig-zag movement of the pulsator, it is necessary to confine the movements of the pulsator to a small zone in the longitudinal direction of the axle and to find the extent of the fracture by following the circular periphery.

4. Sensitivity of the ultrasonics instruments.

It is not possible to give exact figures of the impulse value and amplifying power as these depend on the supply voltage and on the degree to which the tubes have been used.

If the necessary sensitivity has been attained, it must be verified frequently. This is done in the following way.

(*a*) *Reference echo originating from a wheel centre.*

In the case of axles where the wheel seat diameter is not greater than that of the axle, the pulsator is placed on the inner surface of the wheel seat. The ultrasonic wave which, because of the seating pressure, penetrates largely to the wheel centre is then reflected at the outer periphery of the wheel centre and appears on the screen as an echo at line 5, due to the great distance covered by the wave. The transmitter and amplifier knobs must be in such a position that the echo reaches the end of the screen.

As the oldest wheel centres no longer possess a seating pressure good enough for the transmission of the wave, these measurements must be carried out on several wheel centres.

(*b*) *Reference echo on the lathe kerfs of the axle.*

Another method to obtain the correct adjustment of transmitter and amplifier must be used in the case of new axles which have been machined with such a travel of tool that the lathe kerfs are visible, all the more so as these axles hardly show any rust. On such axles, the pulsator is applied so that it is turned by 180° in relation to its normal position, and the beam is directed towards the central part of the axle.

In this case, small echos appear on the screen when the pulsator is moved in the longitudinal direction of the axle. These echos represent reflections of the lathe kerfs.

Transmission and amplification power are so adjusted that these echos do not exceed a height of 5 mm.

5. Characteristics of echos due to flaws.

Signals due to cracks are thin and sharp and clearer than echos due to the tool lines and normal corrosion.

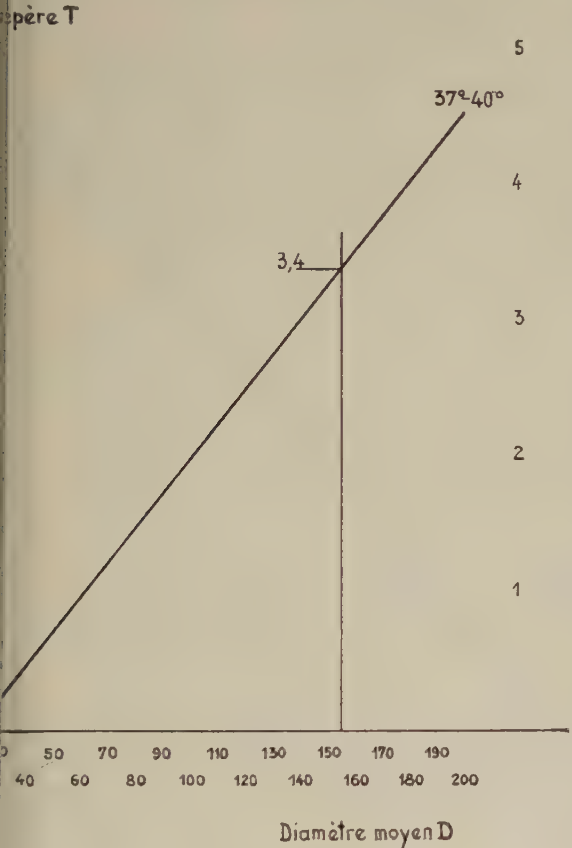


Fig. 6.

Diamètre moyen = mean diameter.
Repère = mark.

If the pulsator is moved to and fro over a distance of a few centimetres in the longitudinal direction of the axle, these signals must move by a few millimetres and, at the same time, their height must vary. Flaws always show up over a great part of the circumference.

During the alternating movement of the pulsator, the shape and height of the echo must be specially observed during the periodical movement of the circuit-breaker.

6. Untimely echos.

During the inspection of axles, many axles will show signals which might be interpreted as flaws by an operator whose experience is limited, or who is not paying full attention.

(*a*) *Within the wheel seat.*

In the case of a small number of axles, one observes, when the pulsator is moved in the longitudinal direction of the axle, echos which arise one behind the other yet are linked with each other by a large base line. The maximum of these echos is always reached at the same mark. According to the values of T and *a*, these echos appear to indicate a number of cracks in the wheel seat spaced at intervals of 1 cm. They disappear when the wheel centre is removed.

(*b*) *Zone outside the wheel seat.*

Another erroneous interpretation of echos may occur in the case of axles with wheel seat diameter greater than that of the axle.

In the zone of the axle close to the wheel seat, somewhat deeper tool traces are sometimes encountered. These lathe kerfs may cause screen echos which are, in height and shape, completely similar to echos caused by defects. However, the distance which the wave must cover

to reach these lathe kerfs is slightly shorter than in the case of a flaw in the wheel seat. These echos appear on the screen slightly in front of the mark corresponding to this axle. For that reason, it is in such cases particularly important that the ultrasonics instrument is well adjusted and operated, and that the mark at which the echo due to the crack should appear is correctly calculated.

The calculated distance *a* of the defect must be measured on the axle. It will then be found that the reflection does not originate in the wheel seat but in the fillet.

If it is, however, suspected that there is a crack in addition to a lathe kerf, especially if the echo is very strong, the spot must be machined and the axle inspected once more. If the defect is no longer visible, the axle may remain in service.

7. Pulsator wear.

The plexiglass surface of the pulsator forming an angle of 37° is subject to wear which has the effect of reducing the path through the plexiglass. As this wear is irregular, the angle of incidence becomes gradually greater. But, if the values of T and *a* do not vary much, it is necessary to ascertain these small modifications as it is on these values that the possibility depends of distinguishing the lathe kerfs from fractures in the wheel seat.

(*a*) *Maximum permissible angle of incidence.*

The greatest angle of incidence that can be admitted is 40°. Beyond that value, the sensitivity of the instrument decreases, and the pulsator must be withdrawn from service. It is not possible to re-finish the pulsator because the length of the path inside the plexiglass is thereby changed to such an extent that it is no longer possible to use simple formulas for the determination of T.

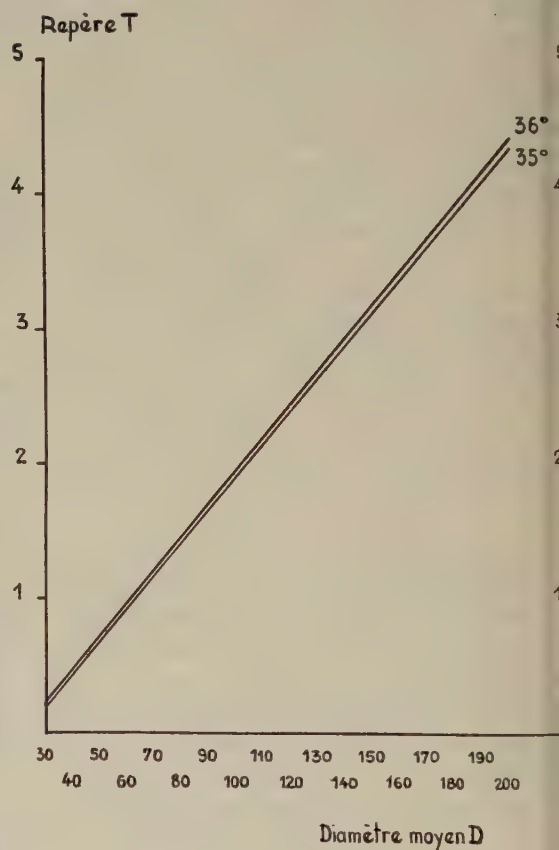


Fig. 7.
Diamètre moyen = mean diameter.
Repère = mark.

The angle of incidence must be checked twice a week. For this purpose, the following standard gauge is used (fig. 8). A steel cylinder of 150 mm diameter and 200 mm length is planed along two parallel

plane surfaces 91 mm apart. This object is marked, on one of the faces, with six lines at a distance of

a = 105, 109, 113, 117, 212.5 and 126 mm

measured from one of the bases of the cylinder, corresponding to angles of

35°, 36°, 37°, 38°, 39°, and 40°

measured from the opposite base.

The degrees are indicated on the standard gauge.

echo obtained from the alternating movement of the pulsator in the axial direction. This is obtained when the central beam reaches the edges. The amplification to be applied is smaller than in the case of the inspection of an axle so that the maximum value of the echo does not exceed the field of the screen.

If the angle of the pulsator is exactly 37°, the red markings of the pulsator coincide with the 37° mark when the

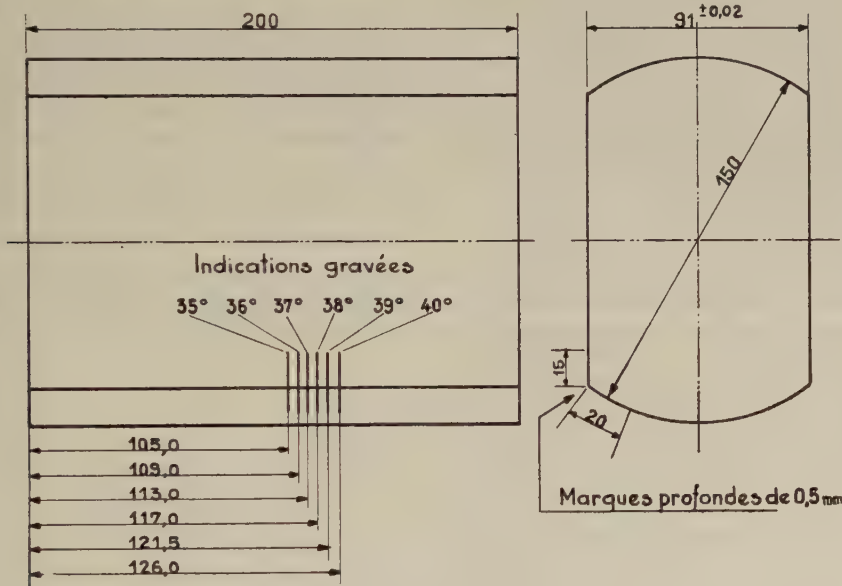


Fig. 8.
Indications gravées = engraved markings. — Marques profondes de 0.5 mm = markings of 0.5 mm depth.

(*b*) *Checking the pulsator.*

For the checking of the angle of incidence, the pulsator must be applied with oil to the round part of the standard gauge between the two marks, with the beam directed towards the base.

It is then necessary to find the maximum echo is obtained. If, owing to the wear of the plexiglass, the angle of incidence of the pulsator has increased, the maximum echo will be obtained when the pulsator is at a greater distance from the base on which the ultra-sound wave falls.

The angle of incidence must be noted

from the position of the red marks in relation to the angle values indicated.

(*c*) *Estimating tan α.*

When the value α of the angle of incidence has been read off, the value of tan α can be taken from the following table :

α	*tan α*
35°	0.700
36°	0.726
37°	0.753
38°	0.780
39°	0.810
40°	0.839

If α has an intermediate value, it is necessary to interpolate.

(*d*) *Using graphs.*

In order to avoid laborious calculations it is recommended to use graphs, showing *a* as a function of D and of angle α, and T as a function of D and α (figs. 3, 6 and 7).

These graphs show for any diameter or mean diameter the different values of *a* corresponding to different angles α. These graphs are very convenient.

CONCLUSION

With the ultrasonic method of examining axles, it is at present possible to detect and remove solid axles which are fractured. The technique as at present used can not yet be applied to perforated or hollow axles as there is obviously no path available for a wave applied to the outside of the axle.

It is however not impossible that the tests which are at present being carried out may eventually lead to satisfactory results. In that case, a further communication will be published in this *Bulletin.*

[625 .28]

Train or railcar for long distance express services ?

by Roman LINDER, Offenbach.

(*Der Eisenbahningenieur*, No. 12, December 1955.)

In the article « Comparison of passenger vehicles for railway, road and air traffic » (Der Eisenbahningenieur, *No. 4/52, p. 80*), *certain indices were given for comparing methods of transport which make it possible to estimate the capacity of vehicles very quickly from the point of view of speed, economy and comfort. Since then a whole series of new railway vehicles have been put into service which it would be interesting to compare in the same way. By means of these indices we will consider later on the question of ascertaining whether it is more economical to use trains or railcars for express passenger services.*

1. — Definition and development of the indices.

a) *Symbols used in the formulae.*

N = power in H.P.; G_b = total weight of train in use in tons; G = total weight of train when empty in tons; G_l = weight of locomotive in service in tons; G_{wl} = weight of special vehicles empty in tons; G_{wlb} = weight of special vehicles in use in tons; G_w = weight of normal vehicles empty in tons; G_{wb} = weight of normal vehicles in use in tons; n = usual number of wagons; p = number of seats in the whole train (number of seats in the coaches, including restaurant-car seats); P_l = number of seats in special vehicles; P = number of seats in the normal vehicles.

By special vehicles, we mean in this instance vehicles which have to be attached to a train for special purposes. Their number per train is fixed *a priori* and remains unaltered (for example : restaurant-cars or luggage vans). The normal vehicles are those whose number in the rake can be altered.

b) *Definition of the indices.*

The *power per ton* gives the motive power related to each ton of the train in use, in other words the *power per ton of the train* (in use). The power per ton makes it possible to measure the acceleration capacity of a train and the speed which it can reach. However, the motive power varies according to the speed for the different motor vehicles, which may affect the acceleration possible.

The *power per seat* relates the motive power to the number of seats in a train; this is therefore the power per seat available. This makes it possible to measure the power required per passenger and consequently constitutes a comparative figure for the cost of a method of transport. At high speeds or with a considerable acceleration power, the power per seat necessarily increases. This index can therefore only be used in making a comparison with the power per ton. As with the railway vehicles now under consideration, conditions do not differ appreciably from one to the other, we will not take this into account in these considerations.

The *weight per seat* gives the proportion of the weight in service of the empty train per seat available, in other words the *weight of the train* (weight in running order) per *seat available.* This value is of capital importance for all methods of transport, because the acceleration, the speed, and ability to climb up gradients depend essentially upon the mass to be moved. Moreover, increased comfort always entails additional weight.

The index *area per seat* relates the floor area available for passengers to the number

of seats; it is therefore the *basic area of the vehicle per seat.* This is a rough guide to the possible comfort of the passenger and is of no importance in the present study because the trains being compared have only very slight differences in this respect.

The following formulae are therefore obtained for the indices :

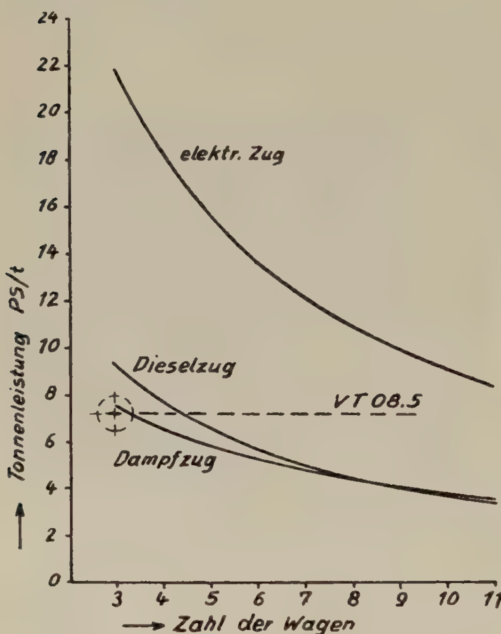


Fig. 1. — Variation in power per ton.

N. B. — Zahl der Wagen = number of coaches. — Tonnenleistung = power per ton. — Elektr. Zug = electric train. — Dieselzug = Diesel train. — Dampfzug = steam train.

Power per ton :

$$\frac{N}{G_b} = \frac{N}{G_1 + G_{w1b} + n \cdot G_{wb}} \text{ H.P./t} \quad (1)$$

Power per seat :

$$\frac{N}{P} = \frac{N}{P_1 + n \cdot p} \text{ H.P./seat} \quad (2)$$

Weight per seat :

$$\frac{G}{P} = \frac{G_1 + G_{w1} + n \cdot G_w}{P_1 + n \cdot p} \text{ t/seat} \quad (3)$$

In these formulae, the seats in restaurant-cars are also counted as being occupied.

In comparing trains and railcars, it is also necessary to compare the purchase price of the trains per seat. These *prices per seat (in DM/seat)* have been estimated. What concerns us here is not so much the absolute value of the purchase price as the exactitude of their ratios.

c) *Calculating the number of vehicles for equal indices.*

To compare railcars with other trains, it is of interest now to ascertain how many coaches a train can consist of to attain the same power per ton as a railcar, or to equal the railcar under consideration from the point of view of weight per seat or the power per seat. Equations (1) to (3) solved in relation to n give a number of vehicles :

from the point of view of the power per ton, of :

$$n = \frac{N}{G_{wb}\dfrac{N}{G_b}} - \frac{G_1 + G_{w1b}}{G_{wb}} \quad (4)$$

from the point of view of the power per seat, of :

$$n = \frac{N}{p \cdot \dfrac{N}{p}} - \frac{P_1}{p} \quad (5)$$

from the point of view of weight per seat, of :

$$n = \frac{G_1 + G_{w1} - p_1 \dfrac{G}{P}}{p \dfrac{G}{P} - w} \quad (6)$$

2. — Railway vehicles in question.

The considerations relating to long distance express trains have been based upon the following railway vehicles :

Type of vehicle	Symbol	Motive power in H.P.	Weight in service in t	Number of seats
Steam locomotive	01	2 200	170	—
Diesel locomotive	V 200	1 820	74	—
Electric locomotive	E 10	4 500	82	—
Restaurant-car	BR 4 ümg	—	37	48
1st & 2nd class coach	AB E ümg	—	37	60

The restaurant car seats were included in the case of the coach BR 4 ümg. As the long distance trains, which are the subject of this comparison, never carry any luggage, no vans were included.

Powers and indices of the express railcars with Diesel engines

Series	VT 06.5	VT 08.5	VT 10.501
Year of construction	1938	1952	1953
Motive power in H.P.	1 128	940	640
Weight in running order in ton	159	120	118
Weight occupied in tons (80 kg per seat)	169	134	129
Number of seats (including restaurant-compartment)	126	138	131
Power per ton (in H.P./t)	6.7	7.0	5.0
Weight per seat in t/seat	1.34	0.87	0.96

The VT 06.5 railcar is the triple express Cologne type railcar, built before the second world war.
The VT 08.5 is the first type designed since the war; it is considered here in its usual form of motor unit, centre coach and driving unit.
The VT 10.501 is the new articulated rail motor coach (day train).

The VT 08.5 has the most favourable power figures per ton and weight per seat. This is the vehicle we have selected as our comparative vehicle in the following study.

3. — Comparison of the express VT 08 railcar with the corresponding long distance trains.

a) *Trains selected for the comparison.*

The train substituted for a VT 08 must have at least one restaurant-car. For this purpose, we have chosen the coach BR 4 ümg. Each train must therefore include this special coach. For the other vehicles, we have chosen the new express AB 4 ümg coaches.

To haul these trains, we will use a series 01 steam locomotive, a series E 10 electric locomotive and a series V 200 Diesel locomotive. For these locomotives, we have calculated from equations (4), (5) and (6) the number of possible wagons for which the corresponding indices will correspond exactly with those for the VT 08 express railcar (see table below). The costs per seat are dealt with separately in the final chapter. In this calculation the restaurant-cars were *not* taken into account.

Number of coaches calculated when the train is hauled by :

	Steam loco BR 01	Diesel loco V 200	Electric loco E 10
For a power of 7 H.P./t per ton	2.3	3.4	11.9
For a weight per seat of 0.87 t/seat	9.1	3.8	4.2

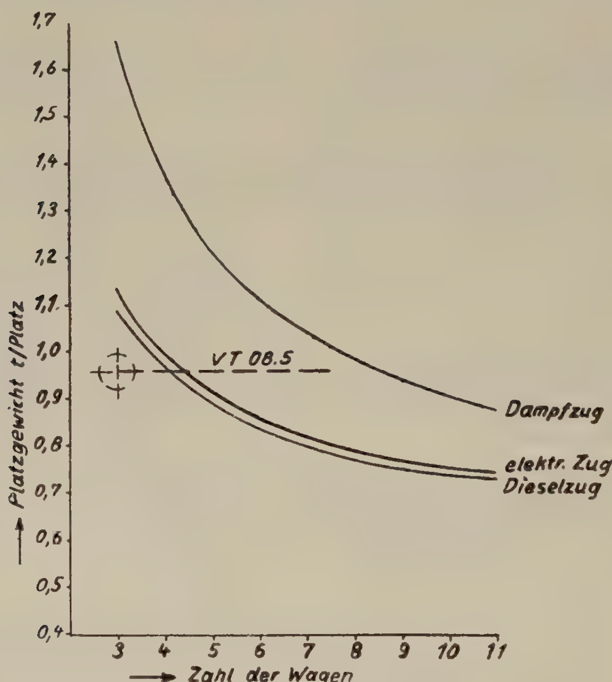


Fig. 2. — Variation in the weight per seat.

N. B. — Platzgewicht = weight per seat.

To get the same weight per seat with the *steam train* as with the VT 08 railcar, it must haul 9.1 normal coaches, but then the power per ton will fall to 1/4 of that of the VT 08. The steam train is therefore *poor* from this point of view.

The train hauled by the *V* 200 *Diesel locomotive* can with the same power per ton as the VT 08 haul one coach more than the steam train; the weight per seat differs very little from that of the VT 08.

The train hauled by the *E 10 electric locomotive* can, with equal power per ton, haul definitely more coaches than the V 200 Diesel locomotive. From the point of view of weight per seat, the E 10 gives results a little less good than the V 200.

We will now compare the indices of the

long distance express trains with each other, for about double the number of seats of the VT 08.

We will compare these trains composed of new coaches with the weights and indices of long distance trains of the same number of ancient coaches, which weigh exactly 10 t more, and will calculate the improvement thus realised.

b) *Comparison of the powers of long distance express trains.*

The table shows that the new coaches, which are lighter and longer, compared with the ancient ones, result in a very considerable improvement in the acceleration capacity and economy. These improvements are felt to the maximum with the light Diesel locomotive; the heavy steam locomotive gives less good results.

The power per ton of the electric train shows an acceleration capacity 2.5 times as great as that of the Diesel train and nearly 3 times as great as that of the steam train.

c) *Comparison of the long distance express trains and the VT 08.*

The trains in question, composed of new coaches, give 2.1 times more seats than the triple VT 08 railcar.

The acceleration capacity, characterized by the power per ton, is, in the case of the steam train 81 %, in the case of the Diesel train 90 %, and in the case of the electric train 218 % of that of the VT 08.

The weight per seat is in the case of the steam train 27 % higher than in the case of the VT 08, in the case of the Diesel train, 1 % higher, and in the case of the electric train, 3 % higher.

Long distance express train with . . .	Steam loco.		Diesel loco.		Elec. loco.		(VT 08)
Series	01		V 200		E 10		(triple)
Power (H.P.)	2 200		1 820		4 500		940
	coaches		coaches		coaches		
	new	old	new	old	new	old	
Total number of coaches	5	5	5	5	5	5	
Number of seats new coaches	288	228	288	228	288	228	136
Weight of train in use, in tons	377	422	281	326	289	334	131
Weight of train, empty, in tons	354	404	258	308	266	316	119
Indices of long distance trains :							
Power per ton, H.P./t	5.8	5.2	6.5	5.6	15.6	13.5	7.2
Weight per seat (t/seat)	1.22	1.77	0.89	1.35	0.92	1.38	0.88
Improvement in the acceleration capacity due to new coaches :							
compared with the power per ton, %	10		14		13		
compared with the weight per seat, %	31		34		33		

If the available capacity of the trains used for this comparison can be fully utilised, it follows that the railcar has no advantage over the Diesel and electric trains used for the comparison from the point of view of weight per seat. The

nearly 10 % greater acceleration capacity of the VT 08 compared with the Diesel locomotive train is not negligible.

Here we have to take into consideration the operating advantages due to the facility of adapting the trains to traffic requirements, as well as the total user of the electrified lines, as well as the advantages of individual coaches from the maintenance point of view.

4. — Variation in the indices of the trains compared with the number of coaches.

The variation in the indices for the long distance trains shows their performance from the operating and traffic points of view. The following table gives the corresponding values :

Number of normal coaches (without restaurant cars)	2	3	4	5	6	7	8	9	10
Steam express train :									
Weight in use	294.4	335.2	377.0	419.8	459.6	501.4	543.2	575.0	628.9
Power per ton	7.5	6.5	5.8	5.2	4.8	4.4	4.0	3.8	3.6
Express Diesel train :									
Weight in use	198.4	239.2	281.0	323.8	363.6	405.4	447.2	489.0	532.8
Power per ton	9.2	7.6	6.5	5.6	5.0	4.5	4.1	3.7	3.5
Express electric train :									
Weight in use	206.4	247.2	289.0	331.8	371.6	413.4	455.2	497.0	540.8
Power per ton	21.8	18.2	15.6	13.6	12.1	10.9	9.9	9.1	8.3
Weight per seat, with									
steam locomotive . .	1.66	1.33	1.22	1.115	1.04	0.98	0.94	0.91	0.875
Diesel locomotive . .	1.09	0.96	0.89	0.84	0.80	0.78	0.755	0.74	0.73
electric locomotive. .	1.14	0.99	0.92	0.86	0.82	0.794	0.77	0.76	0.74

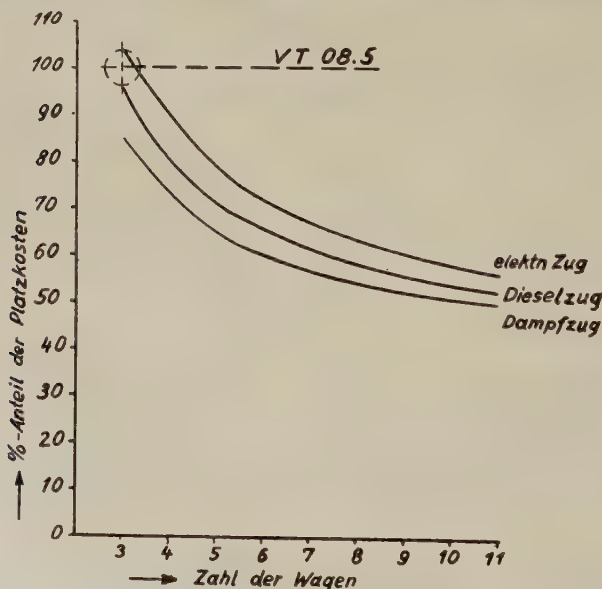


Fig. 3. — Cost of seats in the trains compared with the VT 08 railcar (as a percentage).
N. B. — Anteil der Platzkosten = percentage proportion of the cost of seats.

Figures 1 and 2 represent these calculated indices graphically. The restaurant-car has been included in the total, so that the number of vehicles covers the whole number of wagons. The dotted horizontal line represents the index for the VT 08. The curves show the much greater capacity of the electric locomotive, and still more so, from the point of view of weight, of the train hauled by the Diesel locomotive.

5. — Cost per seat of the trains compared.

The costs per seat reflect the influence of the capital costs upon the economy of a train. The following table, as well as figure 3 give a comparison of the cost per seat in the VT 08 and the costs per seat in the comparative trains, for different numbers of coaches.

Percentage of costs per seat in the triple VT 08 railcar and the comparative trains (cost per seat of VT 08 = 100) :

Number of normal coaches Total number of coaches. .	2 3	3 4	4 5	5 6	6 7	7 8	8 9	9 10	10 11
Steam train.	85	72	65	60	57	54	52.5	51	41.5
Diesel train.	92	77	69	63	59	56	54	52	51
Electric train	104	90	79	72	67	63	60	58	56

The costs per seat are already about equal to those of the VT 08 railcar with a train of three coaches. In the case of longer trains, the costs per seat are less in view of the increasingly small proportion of the locomotive costs.

6. — Résumé.

The comparisons made of the indices do not pretend to be complete, because a whole series of cost factors (operating materials, staff and maintenance) have not been taken into account. The comparison of the methods of transport by means of the power per ton, weight per seat and cost per seat indices will be the more accurate as the differences in the above mentioned costs for the different methods of transport considered are the smaller.

In the present case, the indices show that the *express railcars have no particular advantage over the corresponding trains when their capacity has to exceed some 130 to 140 seats.*

[656 .224

An examination of certain factors which influence the comfort of railway journeys,

by Professor Ir. H.C.A. Van Eldik Thieme.

(*Spoor- en Tramwegen*, No. 20, 29th September 1955.)

If we wish to find out the factors likely to influence the pleasure of a journey, let us imagine some ordinary passengers going to the station to make a train journey. This will naturally bring us into contact with the factors to be considered.

We walk towards the station yard and after having crossed this safely we reach a modern station, both from the point of view of appearance and arrangement. The spacious hall, free from draughts and well sign-posted, makes it easy for the passenger to find the right booking-office where an attentive clerk soon issues him with his ticket. After passing through the control point, a clearly visible train indicator attracts his attention: this shows him which platform he wants, and after going through the subway with its modern lighting, he arrives at the platform where he is not disturbed by too many trolleys dashing along too fast.

When the train arrives at the platform, sufficient time is allowed for it to be boarded so that aged passengers are not upset by piercing whistles. They generally want a 2nd class non-smoking compartment and cannot guess at what point of the platform this is likely to draw up.

The coaches are adapted from the constructional point of view to the type of service for which they are to be used. For short distances, there must be easy access; there will therefore be wide doors, spacious vestibules, plenty of room between the rows of seats, and in addition room for a relatively large number of standing passengers. Although this latter does not exactly make for comfort, there is no reason for complaint as the journey time is short.

In the case of longer journeys, however, greater attention must be paid to comfort; there will therefore be fewer doors, smaller vestibules, large windows allowing passengers to see the view on both sides, and spacious, comfortable seats, fitted perhaps with footrests and adjustable backs. To make the journey still more comfortable, there will be a restaurant, a bar or sleeping berths, and all or at least some of the coaches will be fitted with loud-speakers to make various announcements or relay radio programmes.

Obviously the actual journey and consequently the country in which the stock is to be used, as well as its climate, will have a great influence upon the method of construction of the vehicle. If the summer is long and hot, for example, there will be low windows fitted with shutters and it is essential to provide air conditioning and iced drinks. In some regions, dust is a particular problem necessitating special treatment of doors and windows, so that special joints and a higher atmospheric pressure in the coach protect the passenger from dust. Carrying our investigations even further, we will now consider heat and sound insulation.

Let us first of all consider the *technical side of the sound problem* as regards comfort; to understand this better we must study to some extent the mechanism of hearing.

From the point of view of audibility, the human ear is sensitive to vibrations of from 20 to 20 000 Herz (Hz), we must also consider the perceptibility of a noise, which is determined by its intensity, i.e. the energy transmitted per second and per m^2 by the sound wave.

Experiments have shown that the degree of our acoustic impression is approximately proportional to the logarithm of the intensity. The difference between two sound impressions is therefore given by the logarithm of the ratio of the acoustic intensities :

$$S = 10 \log \frac{I_1}{I_0}$$

For the basic level, the lowest intensity that is audible, $I_0 = 10^{-12}$ watt/m² has been taken, whereas the maximum intensity supported without pain is 1 watt/m², i.e. 10^{12} times the minimum intensity which is barely audible. As a function of the logarithm of the ratios, the difference between these two extreme limits is 12 units or 12 bels = 120 decibels.

Therefore, when it is question of a sound of so many decibels, this means it is being compared with a very low standard sound.

Another measure of sound is the phon. The number of phons in a noise is defined as being equal to the number of decibels in a sound of the same intensity at 1 000 Hz (fig. 1).

The audibility of a sound depends as much upon its spectrum of frequencies as on its intensity. All the noises corresponding to an equi-phon line sound equally loud.

For example : 0 phon is the limit of audibility; 30 phons corresponds to the tic-toc of a pendulum; 50 phons corresponds to the noise in a quiet street; 100 phons corresponds to the noise of a motorcycle; 110 phons corresponds to the noise in a boiler shop.

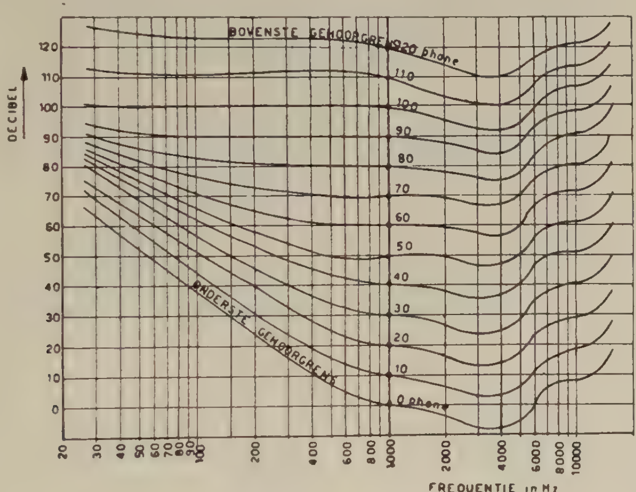


Fig. 1.

N. B. — Frequentie in Hz = frequency in Hz. — Onderste gehoorgrens = lower limit of audibility. — Bovenste gehoorgrens = upper limit of audibility.

Amongst other common noises during a train journey we notice :

a) the shocks at rail joints;

b) the grating, whining and groaning of rails with undulatory wear;

c) various humming noises (converters, gears);

d) the rattling of doors, the grating of brakes, the noise of the fans, etc.

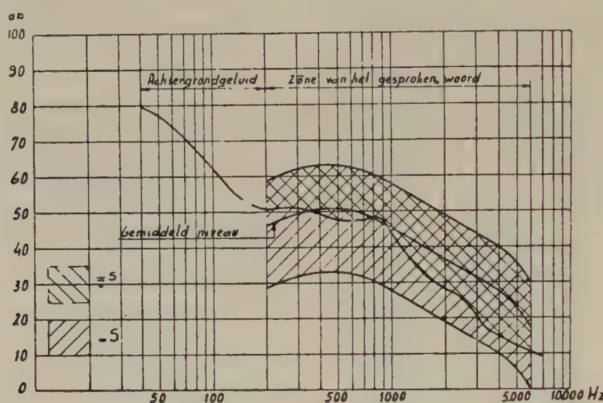
As the admissible noise level in a compartment, we may take as criterion the measure in which it is possible for two

persons sitting side by side to hold a conversation without raising the voice. This gives a so-called index of comprehension, which gives a value of appreciation for the whole zone of frequency of the speaking voice, i.e. approximately between 200 and 6 100 Hz (fig. 2).

In the hatched zone, a listener can understand the speaking voice perfectly. If the spectrum of the measured frequencies of the running noises are traced in this

materials are used, because it takes a lot of power to make these heavy insulating plates vibrate, but the great weight is a disadvantage.

For example, it is possible to reduce the noise transmitted by the plating by the internal friction of materials added to them by sticking them or spraying them on, whilst absorption by friction in the air pores of specially absorbant materials is also possible.



$$\textit{Index of comprehension} = \frac{s}{S} \cdot 100\ \%.$$

Fig. 2.

N. B. — Bemiddeld niveau = average level. — Achtergrondgeluid = background noise. — Zone van het gesproken woord = zone of the speaking voice.

same diagram the index of comprehension I is that part of the hatched surface S expressed as a percentage which is not covered by the spectrum of noises.

$$I = \left(\frac{s}{S}\right) 100\ \%$$

A percentage of I = 60 % guarantees total comprehension; below 30 % comprehension becomes difficult. The admissible level of noise is about 60 phons.

This method does not take into account noises whose frequency is below 200 Hz, the power of which is high, and which are other reasons that explain the sensation of fatigue that goes with a long journey.

Acoustic insulation is possible if heavy

When fighting the sources of noise, the source of the greatest intensity must be dealt with first of all obviously, because there would be no sense in fighting some smaller noise. In other words, the fight against the noises due to the method of transmission is senseless unless the level of the running noises of the coach in the compartment is less than that of the Diesel engines.

Apart from noises due to the movement of the tyres on the rails, the transmission of noise via the air must also be fought, as well as the noises of contact, such as vibrations due to shocks to the tyres which are transmitted through the frame of the vehicle and cause further vibration of the

covering sheets. Obviously the use of pneumatic tyres (fig. 3) and rubber primary suspension have a good effect upon the level of the running noises. Finally, the noise compared with the amount of noise which enters the compartment can be combatted by increasing the coefficient of absorption.

The fight against the vibrations of the doors, the ash-pan and the rattling of the brake rigging is relatively easy, although perhaps costly. The greater level of noise recorded through the windows of a well insulated coach.

The insulating materials used are obviously of the greatest importance. The requirements for a good non-conducting material are amongst others :

1) it must have a small coefficient of heat conductivity;

2) it must prevent the condensation of steam and quickly shed any humidity it may absorb;

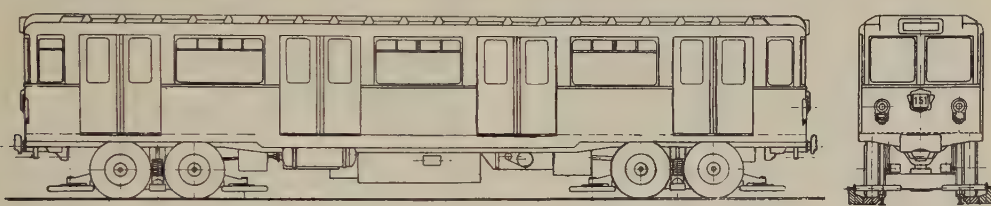


Fig. 3.

close to the floor proves that the latter should preferably be designed as a double continuous heavy floor and particularly good insulation is necessary in line with the bogies especially (fig. 4).

The side walls with their windows are the next most important objectives of insulation and a fixed double framework for the lower part of the windows must be regarded as a compromise from the technical acoustic point of view. The intensity of noise at roof level is relatively small, so that at this point insulation only has a restricted value.

As far as *heat losses* are concerned, however, in the case of steel roofs, there must be good thermal insulation, so that if we combine the thermal and acoustic requirements, with good thermal insulation we shall get the lowest possible coefficient of transmission for the whole vehicle. From this point of view, the roof should be very well insulated as its large area is exposed to the action of sunlight, snow, etc. The windows are always the weak point, thermally and acoustically, because even with double windows 25 % heat losses are still

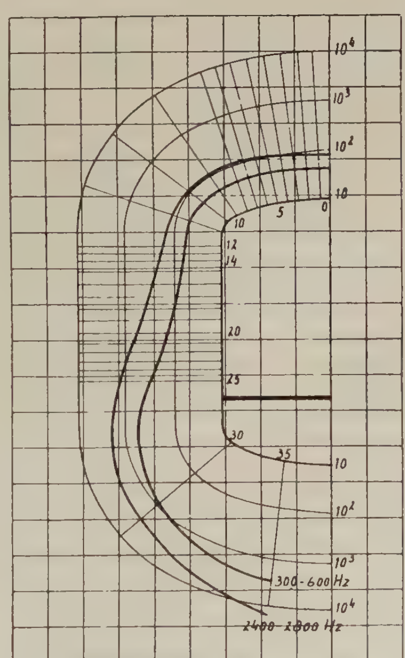


Fig. 4.

3) it must be easy to fix;

4) it must be usable everywhere, even on rigging, webs, uprights, etc., in order to avoid the transmission of heat towards insulated components through parts that have no insulated covering;

5) be free from decay, uninflamable, stand up to shocks, not harbour vermin, be light and dampen out noises.

Although relatively heavy, asbestos fibre is often used, sprayed on; this fibre, mixed with special materials, can easily be fixed to all metal parts of the body. The relatively great weight is however necessary in order to get good sound insulation.

The transmission of heat through the floor, the walls, the windows and the roof can be calculated, so that the total quantity of heat lost per coach per hour for each degree Centigrade of difference of temperature with the outside atmosphere, at a given speed, is known, being for example equal to 500 Kcal/h°.

Figure 5 gives an example of good sound and heat insulation for a passenger compartment.

And now we will leave these problems of insulation for that of air conditioning.

Air conditioning is a process which keeps the temperature, humidity, flow and quality of the air (dust and smoke) within given limits. In the case of certain special coaches it has been adapted as a function of the climate, the length of the journey and the standard of living of the people concerned. In view of the fact that coaches fitted with air conditioning are also well insulated thermally, sound insulation is generally good, so that such coaches can be extremely comfortable.

The zones of comfort have been determined by very extensive trials, both in winter and summer; these showed that these zones are determined by the temperature of the air and the walls, the temperature gradient, the humidity, the movement and purity of the air (smoke, cooking smells). For example the desirable air speed is 0.1 — 0.25 m/sec; any higher speeds give a feeling of draughts.

The temperature desirable in summer is higher than that desirable in winter owing to the difference in clothing.

The zones of comfort are shown in figure 6; the considerable influence of the temperature and humidity will be noted.

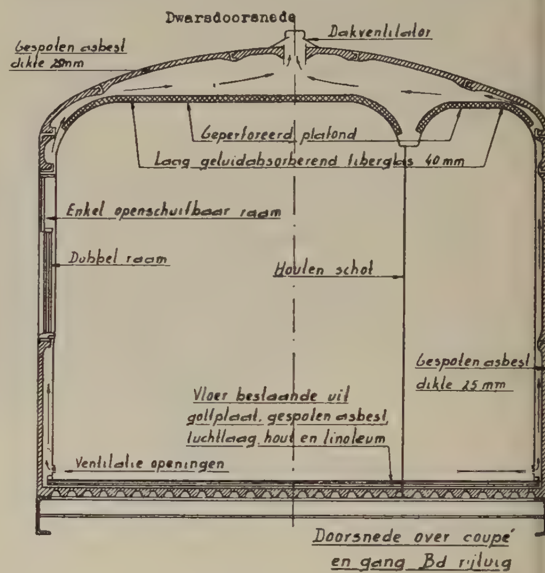


Fig. 5.

Explanation of the Dutch:

Doorsnede over coupé en gang Bd rijtuig = section through a compartment and the corridor of a coach. — Ventilatie openingen = openings for ventilation. — Vloer bestaande uit golfplaat gespoten asbest, luchtlaag, hout en linoleum = floor consisting of corrugated sheeting, a layer of asbestos sprayed on, a film of air, wood and linoleum. — Bespoten asbest, dikte 25 mm = sprayed on asbestos, 25 mm thick. — Houten schot = wooden division. — Dubbel raam = double glass. — Enkel openschuifbaar raam = single sliding window. — Laag geluidabsorberend fiberglas 40 mm = 40 mm thick layer of glass wool for sound insulation. — Geperforeerd plafond = perforated ceiling. — Gespoten asbest dikte 25 mm = 25 mm thick sprayed on asbestos. — Dakventilator = roof ventilator. — Dwarsdoorsnede = section.

In this figure, the relative humidity φ is the ratio between the real pressure of the water vapour and the maximum tension of the water vapour at the temperature of the air under consideration, i.e. :

$$\varphi = \frac{P_s}{P_{s\ max}} \cdot 100\ \%,$$

whilst the absolute humidity is the number of kg of water per kg of dry air.

If the difference in temperature between inside and outside becomes too great, for example 25° C inside and 40° C outside, discomfort is experienced by a « feeling of shock » when leaving or entering a refrigerated space in the summer.

The ideal coach should be equipped with air conditioning equipment which works during stops as well, and is absolutely automatic both in winter and summer. Thus, in the case of a coach in which people

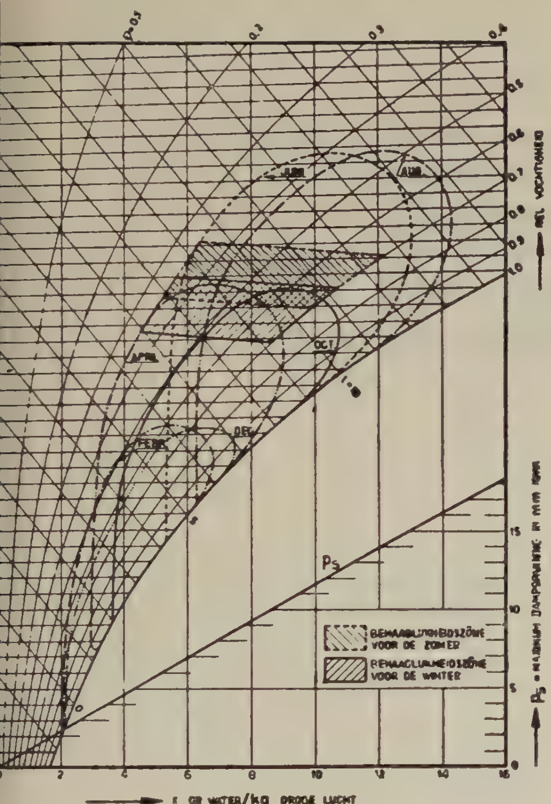


Fig. 6.

N. B. — Gr. water/kg droge lucht = gr water/kg dry air. — Temperatuur °C = temperature °C. — Ps = maximum dampspanning in mm kwik = maximum water vapour pressure in mm of mercury. — Rel. vochtigheid = relative humidity. — Behaaglijkheidszone voor de zomer = zone of summer comfort. — Behaaglijkheidszone voor de winter = zone of winter comfort.

smoke and eat, 78 m³ of air per person per hour should be drawn in during the summer, in the case of a fully occupied coach, 30 m³ per hour per person being fresh air and the remainder recirculated air, which has been purified in the filters and then returned to the compartments.

The air outlet pipes must be short, so that there is fresh air by all the seats. The compartments must always be at a slightly higher pressure so that no smells can come in from the kitchen or toilets.

When a complete train is to be equipped with air conditioning, the passages between coaches must be made air-tight and double fixed windows, etc., must be provided, to prevent any losses of hot or cold air.

Nor must *hygiene* be overlooked; attention must be paid to the seats which form likely hosts for bacteria and smells; likewise in the W. C. and all contact surfaces; the toilet must have a suitably arranged tap; there should be wastepaper basket, etc.

The designer of coaches must also be a good interior decorator and take care of the general appearance, make his seats comfortable, and harmonise his colours, so that the whole compartment is tastefully finished. Large, blatant advertisements are to be avoided, in spite of their commercial advantages.

The passenger is now installed on a comfortable seat in good acoustic and thermal conditions, in pleasant surroundings. If he looks out of the window, the town architecture should have provided a pleasant outlook all along the line, whilst the designer of bridges must have restricted the view of the banks as little as possible.

If the passenger wishes to read, not only the lighting, but the *running* must be excellent; this latter point is the joint concern of the designers of the coach and of the permanent way, though naturally their maintenance also plays a great part.

It is known that the wheels of a single axle are fixed rigidly thereto and that the tyres with the flanges are given a conical shape, seeing that the path to be travelled on curves differs for the wheels according to whether they are on the inside or out-

side of the curve. As on a curve the outer wheel with its flange presses against the outer rail, it runs on a larger diameter than the inside wheel, which diminishes the pivotting of one of the wheels, which is inevitable, when running through a curve, and favours the actual running in this way.

An axle running freely on a track on the straight describes an undulating movement known as « hunting ». Let us consider for example the starting off of an axle having its right hand flange against the rail, so that this wheel will run through a greater diameter than the left wheel whose flange is further away from the left rail on account of the existing play. The right wheel therefore runs over a slightly longer path and gets somewhat in front of the left wheel so that the axle turns towards the left rail; the left flange then hits up against the left rail and it is now the left wheel that is running through a greater diameter so that the axle returns towards the right rail; this movement is continually repeated and this sets up hunting.

Klingel, as far back as 1883, devised a formula for this from which it results that the path taken by the axle is a sinusoid, the length of the wave l of which is :

$$l = 2\pi \sqrt{\frac{RS}{2j}} =$$

$$2\pi \sqrt{\frac{0.5.1.5}{2 \cdot \frac{1}{20}}} = 17 \text{ metres,}$$

a formula in which : R = the radius of the tyre; S = distance from centre to centre of the rails measured above the running circles; j = the conicity of the tyre.

This formula for which the figures given in the example were selected arbitrarily shows that the length of the wave increases if the conicity of the tyre is reduced. As a result the greatest possible conicity is given to the tyre.

The frequency f, i.e. the number of times per second that the axle moves towards one or other rail is given by :

$$f = \frac{V \text{ km/h}}{3.6.l} = \frac{100}{3.6 \times 17} = 1.6 \text{ Hz,}$$

whilst the lateral acceleration b of the amplitude a cm is given by the formula :

$$b = 4\,\pi^2 f^2\, a \text{ cm/sec}^2.$$

With a fairly pronounced conicity of 1 : 7 and a speed of 100 km (62 miles)/h where the flange of the tyre and the railhead are worn, there may be an amplitude a = 2 cm and an acceleration of about 300 cm/sec².

As a result of wear, the initial profils of the tyre and railhead change their shape, a hollow occurring in the tyre (fig. 7).

The increase in the conicity of the running surface results in an undesirable reduction in the wave length of the movement of the axles to and fro between the rails. For this reason, it is desirable that the tyres of coaches intended for high speeds should be turned up every 50 000 to 80 000 km (31 000 to 50 000 miles). Although effective, this is a very costly measure. The maintenance of the track must also receive due care. For example, there should not be lateral irregularities nor any « hollows ». The fact that the condition of the track has a great effect on running quality is well known to the passenger; in fact certain lengths of line are renowned for their discomfort.

It is easy to understand that owing to lateral irregularities in the track, the shocks of the tyre flange are so upsetting, that even the usual hunting movements take second place, so that the value of the wave length calculated as above becomes quite different.

The trajectory of the axle on a line in a bad state of repair is determined amongst other things by the violence of the shock and the elastic reactions of the components concerned. For each axle a « standard trajectory » is set up on the

section in question and this path depends amongst other things on the rigidity of the track, its gauge and the number of irregularities, i.e. on its state of maintenance.

As each axle follows this standard trajectory, the conicity of the tyre can only affect the amplitude of the deviation, so that it is possible to speak of resonance when the wave length of the standard trajectory is more or less equal to that which the sinusoidal trajectory of the axle would take. This implies therefore a over towards the other rail once more. The axle will then stick against the left rail until here again this movement is reversed.

Such factors influence to a great extent the frequency of the so-called sinusoidal movement, so that it is very difficult to predetermine this latter. The section of line seems to have the preponderating influence as far as this problem is concerned.

In actual fact, the study of the problem of running is much more complicated, even

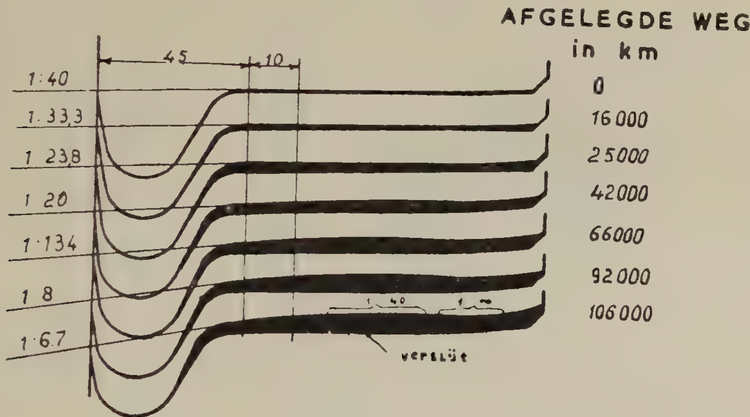


Fig. 7.

N. B. — Afgelegde weg in km = distance travelled in km. — Verslijt = wear.

variable wave length for the standard trajectory of 15 to 35 m for example, so that a band of critical frequencies can occur which will give rise to uncomfortable running, due for example to the rocking of the body by this accelerated hunting movement.

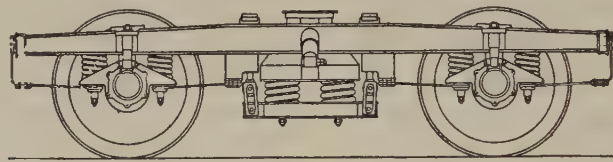
If the force of acceleration thus produced is greater than the available friction between wheel and rail, the flange of the tyre can, according to Sperling, be as it were stuck against the rail for a certain time, contact between the head of the rail and the right flange, for example, being lost until the accelerating effort having been sufficiently reduced, the hunting movement can recommence and the axle move with a body supposed to be rigid. We have only examined the lateral horizontal movements of the axle and body; but the body taken as being rigid can already be animated by six movements : three longitudinal movements and three rotary movements in relation to three perpendicular axes. Apart from these six principal movements of the body, there are oscillations due to elasticity of the body itself, i.e. the oscillations of torsion and flexion. In addition to these free oscillations, there may be forced oscillations due to outside disturbing forces, which may be due to irregularities and the elasticity of the track, to the rail joints and the sinusoidal trajectory of the axle. The construction of

the bogie plays a great part here. For example, we have shown a modern bogie in figure 8.

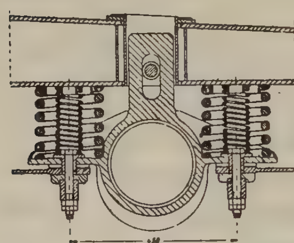
The examination of the problem of oscillations, valuable from the technical point of view, would take a great deal of time, so that we have limited ourselves to the *methods of appreciating* the running qualities and the discomfort of oscillations.

It is often difficult to express an opinion on certain differences because there are no universally agreed standards as regards the oscillations tolerated and if we confine ourselves to the annoyance caused to the passenger, it must be recognised that this is a very personal matter and depends also upon the time to which he is subjected to such vibrations.

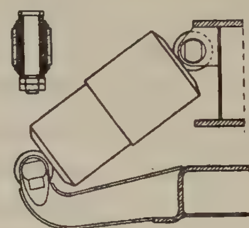
It is above all when the mechanical vibrations are accompanied by disagreeable noises, that it is very difficult to establish any criterion, so that it is better to study mechanical and acoustical vibrations separately.



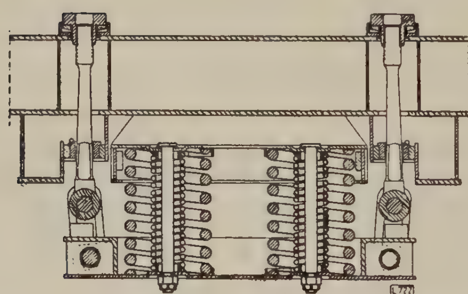
« Minden-Deutz 50 » type bogie.



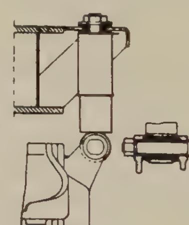
Axle box suspension.



Swing bolster shock absorber.



Swing bolster suspension.



Axlebox shock absorber.

Fig. 8.

A man can become accustomed to vibrations by the setting up of a natural defence, but obviously there is a certain limit, just as in the case of fatigue of materials. The influence of vibrations on a man can extend to the whole of his body or only to a certain part, and need not necessarily be equally pronounced over the whole of the human body; this depends to a great extent upon the scale of frequency of the vibrations.

Each human organ is suspended from the skeleton by means of a ribbon like structure, i.e. a kind of spring, so that it can be considered for our purpose as a system of elastic masses linked up to the skeleton with or without any amortisation.

The organs can easily adapt themselves to a constant acceleration which produces a constant influence, a constant effort; there is therefore equilibrium. A continual variation in the acceleration demands a continual change of equilibrium and may upset the working of the organ concerned.

The variation in the acceleration is therefore the essential cause of the disturbance felt. It appears that the most sensitive organ is the balancing system, especially the functioning of the ossicles on the sound nerves; the zone of sensitivity appears to be 10 cm/sec^3. The extent of the variation of acceleration per unit of time appears to have a great influence upon the upset experienced by a person, as for 1.5 m/sec^3, 30 % of people suffer from seasickness but apathy already appears by 0.3 m/sec^3 after a quarter of an hour.

Those who because of their kind of work are accustomed to great changes in acceleration, stand them easily. There is therefore a certain acclimatization. But if the outside cause is removed, the unconscious reaction continues to produce its effect, i.e. the reaction which compensates for the real movement. The internal reaction therefore continues, which is why after a long sea voyage or air journey, the bed still seems to move in the house, or we still feel as though we are moving along after a train journey.

The power of protection depends to a great extent on the condition of the nervous system, so that under poor conditions, human resistance can be greatly impaired. This depends for example, on fatigue, infectious illnesses or psychic contractions, etc.

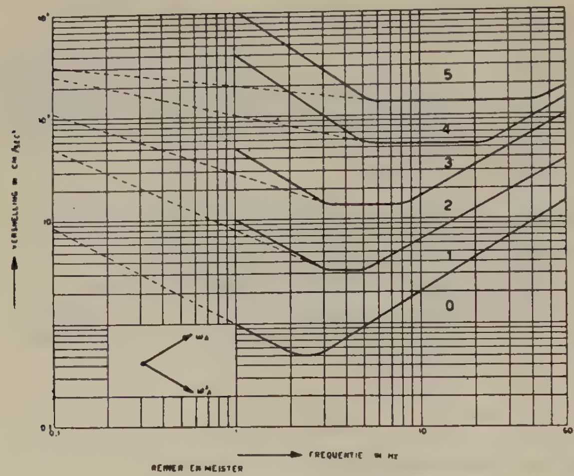
When establishing a standard for the disturbance due to vibrations, we have to be on the safe side and go to low values, to satisfy the most exacting persons. Experimental results, obtained with normally balanced persons, must always be used with prudence.

There also seem to be characteristic zones depending upon the frequency of the vibration. The zone of low frequencies, 0-1 Hz, has been discussed as far as sea-sickness is concerned. If the frequency increases, it is the hearing that plays an ever increasingly important part. With 3-5 Hz, there is a buzzing in the head, for 25-40 Hz disturbance to keeness of vision. No doubt, there is here a limit in the speed of perception when reading. At 35 Hz, there may be trouble with the nervous system which controls the blood vessels, viscera, glands and other parts, with a resulting shortage of blood in the brain, poor vision, whistling in the ears, etc. At 60-90 Hz, there is for example resonance, in its cavity, of the eyeball, and split vision.

Although these phenomena are only gone into incompletely, it is clear that such excessive vibrations cannot be allowed in the case of railway transport. We are giving a brief review of the results of trials carried out amongst others with railway transport.

Research workers like Reiher and Meister have examined the effects of vibrations with frequencies of 3 to 70 Hz on human beings placed on vibrating tables, such vibrations being unaccompanied by harmonics or noise.

The results of these trials and others are given in the diagram of figure 9, which shows that certain criteria, such as the amplitude of acceleration and the frequency can be taken into consideration in determining the degree of comfort.

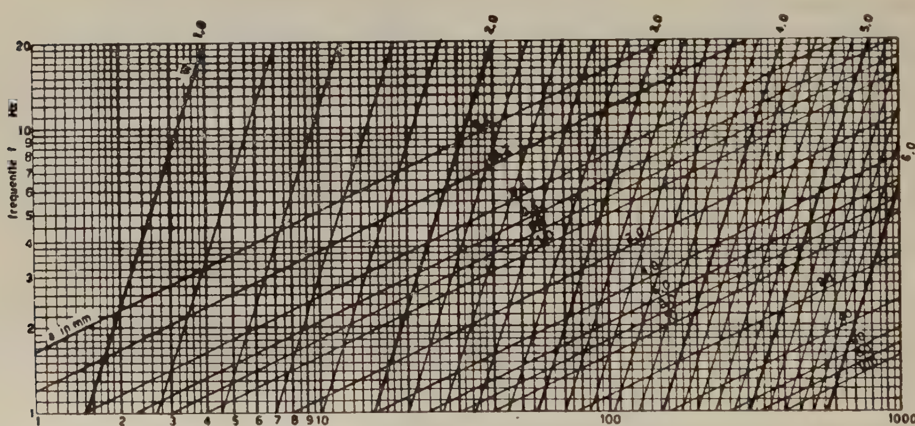


0 = imperceptible.
1 = barely perceptible.
2 = clearly perceptible.
3 = strongly perceptible (tiresome).
4 = disagreeable.
5 = insupportable.

——————— Reiher & Meister.
- - - - - - - - - - (Nieuwenhuizen) long period under stress.

Fig. 9.

N. B. — Frequentie in Hz = frequency in Hz. — Versnelling in cm/sec² = acceleration in cm/sec².



Relation between frequency, amplitude, acceleration and index of easy running.

Acceleration max b in cm/sec².

$$W = 2.7 \sqrt[10]{a^3 f^5} = 0.096 \sqrt[10]{\frac{b^3}{f}}$$

a = amplitude in cm.
f = frequency in Hz.
b' = maximum acceleration in cm/sec².
W = index of easy running.

1.0 = very good.
2.0 = good.
3.0 = satisfactory (limit desirable for passenger coaches).
3.5 = still satisfactory.
4.0 = not so good (limit desirable for freight stock).
4.5 = insufficient.
5.0 = dangerous.
6.0 = very dangerous.

HELBERG & SPERLING : Verfahren zur Beurteilung der Laufeigenschaften. — *Organ*, June 1941.

$$W = \sqrt[10]{W_1^{10} n_1 + W_2^{10} n_2 + \ldots\ldots + W_n^{10} n_n}$$

for successive vibrations n_1 = percentage of vibrations for W = W

$$W = \sqrt[10]{W_1^{10} + W_2^{10} + \ldots\ldots + W_n^{10}}$$

for vibrations produced simultaneously.

Fig. 10.

Sperling also prepared a similar diagram and supplied units of measure for comfort (fig. 10).

With such criteria, we should always remember the objective in view, seeing that those submitted to the trials knew why they had to give the amount of disturbance.

Thus other criteria would be required for a sick room than for an aeroplane cabin or bus compartment. It is natural that the criteria of comfort should differ on aeroplanes, motorcars, trains, houses, etc.

From the above, it is clear that it is possible to give figures for the running qualities of vehicles by measuring the amplitude or acceleration of the vibrations compared with given conventional criteria. In recent years in particular, in many countries active researches have been carried out in this direction.

At the beginning of this report, it was a question of a train starting up without shocks, so that out passenger is still seated in his comfortable compartment which is running along agreeably and if necessary is well lit. Mention has also been made of the various facilities enjoyed during the journey, such as the possibility of having a meal or resting. In addition, the staff with whom the passenger comes in contact must be agreeable, polite and helpful, each one doing his best to make the journey pleasant. The time has arrived when without shocks, the train is gradually braked and comes to a stop, marking the end of our journey.

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[625 .234]

Air-conditioning, a prerequisite to comfort on railways,

by J. de la Puente.

(*Ferrocarriles y Tranvias*, February 1955 issue.)

Owing to the constant progress in air and road travel, and the advantages which these offer to the traveller, it has become necessary to step up the improvement of railway services. The railway administrations throughout the world have paid the greatest attention to such measures lest the railways cease to be the principal means of inland passenger transport.

Fig. 1. — The « TAF » train, manufactured by FIAT, which ensures the service on Spanish railways with the marked improvement of air conditioning.

The condition of the tracks, the quality of the rolling stock, the speed of the trains as well as the elements required for the comfort of passengers : seats, dining rooms and sleeping compartments, have been constantly improved.

However, until air conditioning was adopted (using this term in its narrow sense), it has not been possible to eliminate the drawbacks inherent in railway travel, e.g. dirt, smoke, and climatic changes.

Air fans, heating, forced ventilation by means of filtered air, etc. represented merely temporary and imcomplete improvements in order to attenuate these drawbacks which were finally eliminated by air conditioning.

It is an error to assume that air conditioning is not necessary if the climate of a country is not particularly hot. It may be sufficient to recall that, in the confined space of a passenger coach, it is unavoidable to experience the unpleasant sensation produced by the rise in temperature due to the ambient heat outside, to solar heat, and to the heat generated by the passengers, to which must be added

the no less unpleasant impression of breathing air which is more or less vitiated by dirt, odours and dust.

The Spanish railways, always concerned about the comfort of the travelling public, did not wish to lag behind. Starting with the Talgo trains which have done so much to raise the world prestige of Spanish railway technique, and continuing with the acquisition of the TAF trains

manufactured by the British firm J. Stone & Co., which has great experience in this field and has studied and supplied most of the air-conditioning plants for railways throughout the world, with the exception of the United States. These plants work satisfactorily under extremely varying conditions as regards types of railway, distances, track gauges and climatic conditions.

Fig. 2. — Interior of a single-class car of the TAF train.

from the Italian FIAT Company (Figs. 1 and 2), the Spanish railways have offered their passengers the advantages of air conditioning, to which the public has responded by showing an obvious preference for these trains.

In view of the interest which air conditioning has evoked with the public, we shall give below a general description of the basic features of this system,, taking as example the one used for the TAF trains, as these are the most popular trains, and as the Stone air conditioning system is the one which is going to be used in the new Talgo trains which the Spanish National Railways have ordered.

These air-conditioning plants have been

In Spain, Messrs. J. Stone & Co. are represented by the « ADASA » Company, who manufacture air-conditioning and lighting plant for trains under licence of that firm.

The Stone air-conditioning system is of the electro-mechanical type and based on the cooling effect obtained by using an electrically operated compressor as heat pump.

The necessary power is supplied by electric generating sets which are supplied by the manufacturers of the trains and are placed in the front part of the motor coaches. The electric generating sets, consisting of a Diesel engine and generator, are equipped with a control system

by which the necessary A.C. voltage and frequency used for the air-conditioning equipment can be kept constant. Each generating set is able to feed one motor coach and one trailer. The D.C. required for the control gear, ventilators and fans is supplied by the dynamo and batteries installed in each car.

four-cylinder compressor of variable capacity which has the special feature of working automatically in accordance with the heat load of the car, with one, two or three cylinders idling, thus avoiding the need for frequent stops and re-starts of the apparatus. The cooling thus works in a progressive and continuous way and

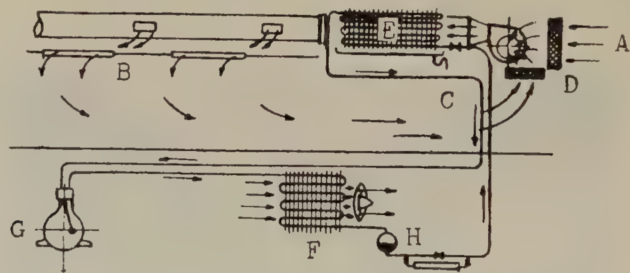

Fig. 3. — Working of the electro-mechanical air-conditioning system.

A = outside air; B = conditioned air; C = return air; D = filter; E = conditioning unit; F = condenser; G = compressor; H = tank for condensed liquid.

Each car is equipped with independent Stone-Carrier air-conditioning equipment, essentially consisting of the following parts (Figs. 3 and 4) :

a) motor-compressor set;

b) condenser;

c) air-conditioning units (evaporator and air heating);

d) ventilators, exhaust fans and filters;

e) air distribution system, ducts and inlet panels;

f) floor heating;

g) conditioning control;

h) cooling fluid and ducts for this fluid; electric leads and accessories.

Figure 3 shows schematically the working of the air-conditioning plant, with the most important elements and the circuits for the circulation of air and cooling fluid.

A. *Motor-compressor set.*

This set is mounted below the car underframe. The A.C. motor operates the permits the maintenance, in the evaporator, of a constant temperature independent of the heat load.

B. *Condenser.*

Likewise mounted below the underframe, the condenser serves to cool, by means of fresh ambient air which is blown in by fans driven by an A.C. motor, the coils containing the highly compressed cooling gas, and to liquefy the latter.

C. *Conditioning units.*

These units are mounted in the roof. The cooling liquid under pressure reaches the expansion valve which permits the passage of a quantity that varies with the evaporator temperature so that the latter remains constant. When the cooling liquid passes from the expansion valve to the evaporator - coils, it expands and, in doing so, absorbs heat from the air flowing through the evaporator so that the latter is cooled and part of its water contents is condensed which is collected in suitable tanks and evacuated to the

outside by special ducts. This air, propelled by centrifugal fans coupled with the air-conditioning units, passes through the air ducts and the inlet panels to the interior of the car.

When heating is required, the compressor is cut out, the air passes the coil which, in this case, is not in action and, before reaching the fans, passes through a set of electric heating units which are otherwise not in action, and which now serve to heat the air. Subsequently, as during the cooling period, the air is released into the interior of the car through the inlet panels.

The conditioning units are fitted with air deflectors or regulators which, when open, enable part of the return air circulating in the conditioning unit to by-pass the evaporator. This device, in conjunction with the working of the expansion valve and with the device allowing the capacity of the compressor to vary, permits a very accurate and progressive temperature regulation.

D. *Blowers, exhaust fans and filters.*

The blowers, which are of the centrifugal type and operated by a D.C. motor, are coupled to the air conditioning units as already explained and, in conjunction with the exhaust fans and the air outlets, produce the air change at speeds and quantities suitably rated to ensure maximum comfort to passengers. Three-quarters of the air flow entering the interior of the car every minute consists of filtered return air, coming from that car, and one-quarter of outside air, likewise filtered. The air in the car is thus completely changed every four minutes, corresponding to fifteen complete air changes per hour. This air is completely free from impurities as it has previously passed through the coresponding filters. Inside the car, a slight excess pressure is always maintained in order to avoid the infiltration of dust from outside.

The exhaust fans and filters are placed

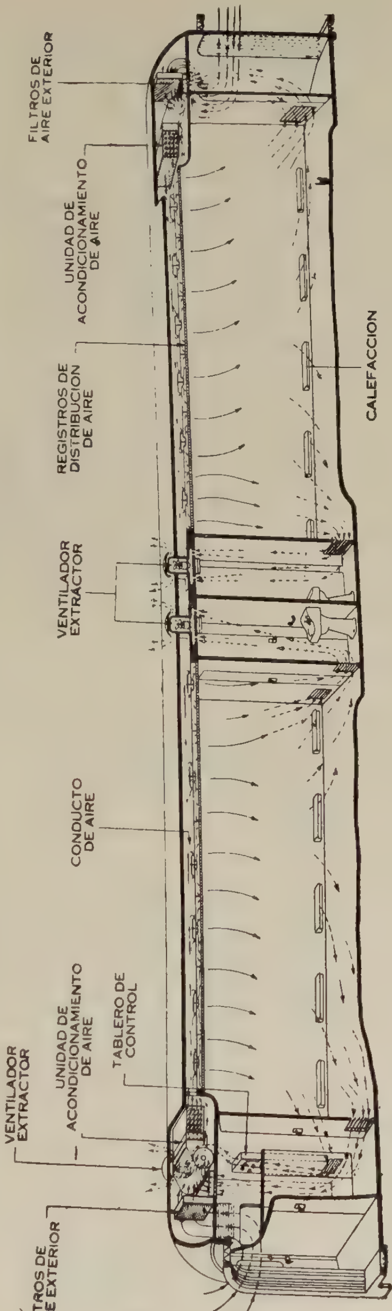

Fig. 4. — Normal arrangement of the component parts of an air conditioning plant.

N. B. — Filtros de aire exterior = filters for outside air. — Ventilador extractor = exhaust fan. — Unidad de acondicionamiento de aire = air conditioning unit. — Tablero de control = control board. — Conducto de aire = air duct. — Registros de distribución de aire = air distribution regulators. — Calefacción = heating.

at the most suitable places and the air outlets are installed in the lower part of the doors inside the cars.

E. *Air distribution.*

The air is distributed by means of ducts which run along the central part of the roof, and which are connected with the multiple-aperture inlet panels. The panels are adjustable and permit, because of the great number of apertures, a soft inflow of air which does not produce draughts objectionable to passengers.

F. *Floor heating.*

As a complement to the hot air heating system, radiators are used which consist of electric resistances, conveniently distributed in the lower part of the side walls of the vehicles and automatically switched in by means of their thermostat controls if the temperature inside the car drops below a given value.

G. *Conditioning control.*

The conditioning controls, of the « Vapor Heating Corporation » system, are mounted on a control board which is contained in a cabinet on one side of one of the car platforms and which can be sub-divided into three panels.

The top panel carries a general control circuit breaker for the air conditioning system, a cooling selection switch and a heating commutator switch, permitting the choice between four cooling temperatures and four heating temperatures. On this panel are also mounted a general D.C. relay for the control and operation of the blowers and exhaust fans, the control relays and pilot lights indicating the equipment operating, and its correct working.

The top panel carries the switches for the ceiling and floor heating as well as the pre-cooling switch. The bottom panel, finally, carries the switches operating the cooling equipment, those of the condenser and compressor motors, as well as of the delta-star starting device of the latter motor, and the thermal protection circuit breakers of the two motors and a no-volt protection relay in the A.C. supply.

The cabinet on the other side of the same platform contains a watt meter relay which compensates the voltage variations of the D.C. supply of the control board, and maintains a perfect regulation of the system, as well as the high-pressure and low-pressure interrupters of the cooling fluid which ensure an adequate protection of the system.

Moreover, one of the enclosures containing the filters and return inlets, arranged on the inside on each side of the top part of the passenger compartment, viz. the one situated on the same side as the control board, also contains the thermostats for the indication and control of the cooling equipment and two thermostats controlling the D.C. motors which operates, by means of gears of high reduction ratio, the air regulators (one for opening and the other for closing). These three thermostats control the effective temperatures. The same enclosure also houses a water supply device for the moist wicks of the thermostats, consisting of a filter and a level regulator.

The enclosure on the other side of this end contains two thermostats which control the ceiling and floor heating, respectively, and which indicate the normal temperatures.

All the thermostats are of the modulating type (Fig. 5) and carry a supplementary bulb to which an electrically heated thermic coil is applied so that the ther-

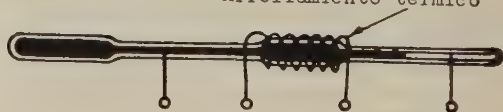

Fig. 5. — Thermostat of the modulating type.
N. B. — Arrollamiento térmico = heating coil.

mostats can be set for certain temperatures. Due to this device, the thermostats predict the service requirements and avoid excess if they are suitably combined with the control relays. The effects of thermal inertia in the air-conditioned system are thus avoided, and a high precision and accuracy of working is ensured.

H. *The cooling agent and its ducts; electric leads and accessories.*

The cooling agent used is Freon ($C\ Cl_2\ F_2$) which is universally used because of its great advantages. Apart from its specific physical properties, this substance has the advantage of being neither toxic nor inflammable. The ducts in which this substance circulates are made of copper of special characteristics, suitable for cooling. The electric leads are conveniently distributed along the car and electrically well insulated, just as the cooling circuits are provided with a good thermal insulation.

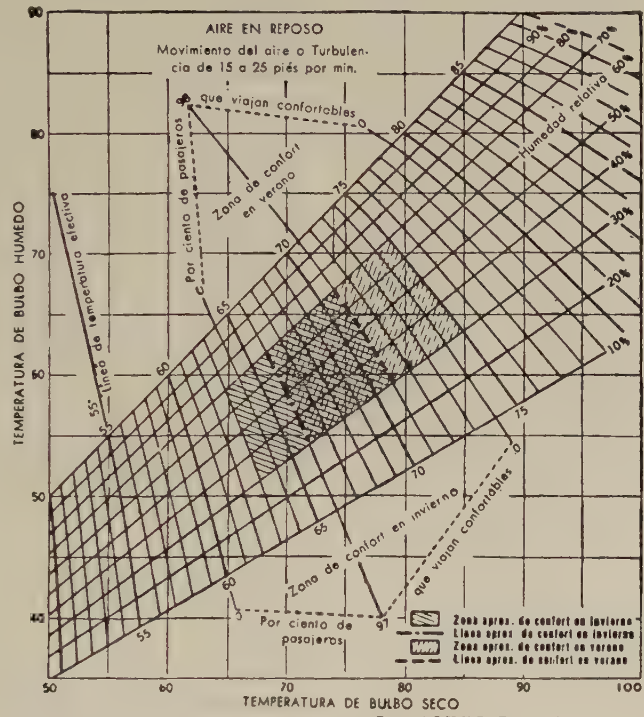

Fig. 6. — Comfort diagram.

N. B. — Aire en reposo = air at rest. — Movimiento del aire... = air movement or turbulence of 15 to 25 ft pr. min. — Por ciento de pasajeros que viajan confortables = percent of passengers who feel comfortable. — Zona de confort in invierno = winter comfort zone. — Zona de confort en verano = summer comfort zone. — Temperatura de bulbo seco = dry bulb temperature. — Temperatura de bulbo humedo = wet bulb temperature. — Humedad relativa = relative humidity. — Zona aprox. de confort en invierno = approximate comfort zone, winter. — Linea aprox. de confort en invierno = approximate comfort line, winter. — Zona aprox. de confort en verano = approximate comfort zone, summer. — Linea aprox. de confort en verano = approximate comfort line, summer.

The équipment also includes a whole series of accessories, such as regulating valves, inspection holes, pre-conditioning connections, anti-vibration suspensions, general circuit breakers, inlet commutators etc. which permit a complete control of all parts and guarantee the reliability of working.

The car is likewise heat-insulated and has double windows in order to improve this insulation and to avoid that the windows become covered with vapour.

In conclusion, we should like to add some brief notes on the « comfort temperatures », a question which is the subject of numerous discussions although it has been perfectly elucidated by the numerous and detailled studies carried out by the leading technical centres for air-conditioning whose experience and competence is beyond doubt. The results of these studies are plotted in the graph (Fig. 6) which is recognized, with some slight variations, by all the authorities concerned with air-conditioning. The underlying principle is as follows :

The condition of comfort requires the pressure of a current of pure and clean air, uniformly distributed over the whole car at an appropriate speed, and at a temperature and a degree of humidity comprised in the comfort zones shown on the graph.

It will be seen that this graph shows the dry bulb as well as the wet bulb temperatures, the straight lines of relative humidity, and the curves of effective temperatures.

By effective temperature is understood the whole constellation of conditions : temperature, relative humidity and air movement, which give the human being a feeling of comfort equivalent to that which would be brought about by the same temperature, measured at a dry bulb thermometer, with the same air movement, and in an atmosphere saturated with humidity.

For example : for a given air movement, every point of the curve of effective temperature of 70° F entails a feeling of comfort similar to that which would be experienced with a dry bulb temperature of 70° F with 100 % relative humidity. In other words, at a dry bulb temperature of 75° F and 50 % humidity, or at a dry bulb temperature of 80° F and 15 % humidity, etc., the passenger must experience the same feeling of comfort.

The curves of effective temperature shown in the graph show the feeling of comfort on a very large scale. Also shown are the « comfort zones » for summer and winter, obtained as the result of numerous statistical tests.

The air speed has a marked effect on the effective temperatures, since the higher the speed, the lower is the effective temperature. But this speed is limited, in practice, by the unpleasant effect produced by the air currents. The normal speed usually regarded as adequate is between 15 and 25 ft per minute.

All that remains to add is the statement that air-conditioning has undoubtedly come to be regarded as an indispensable feature not only on railways but in all manifestations of modern life.

[625 .26 (44)

Painting coaches in the Landy shops,

by M. VERSTRAETE.
Ingénieur, Chef de l'Arrondissement des Ateliers de Paris Nord

and M. VIALATOUX,
Chef des Ateliers chargé du Service des Méthodes.

(*Revue Générale des Chemins de fer*, August 1955.)

The operations of painting and treating the surface, in general, are of particular importance in repairing passenger rolling stock.

The *quality* of the work carried out during these operations has a direct influence upon the good appearance of the coaches as well as the way they stand up in service.

The *cost* is generally very high, owing to the quantity and price of the products used, as well as the heavy labour costs. For example, the cost of completely repainting, after stripping, a metal suburban coach, amounts to nearly 20 % of the total cost of the general overhaul, and more than 350 kg (771 lbs.) of paint or varnish are used.

The *time* taken for the job, which depends upon the number of coats and the time they take to dry represents nearly 25 % of the time the vehicle is out of service for the general overhaul.

On the other hand, in recent years, new techniques have arisen; their use is becoming general in every section of industry. It appeared of interest to profit by this evolution and try to adapt it to the problems proper to the repair of railway rolling stock.

To put these new methods into service, the *human factor* had to be taken into consideration above all, so as to make sure that the working conditions for the men conformed to all the rules of hygiene and safety, and to reduce fatigue and wasted efforts as much as possible.

These reasons led the Landy shops to study the organisation of the work for the whole of the painting shops on a time study basis [1]. This study to begin with covered the following two points in particular :

— treating separate components taken down from the vehicles during periodic overhauls. This will be dealt with in a later article in this journal;

— the use of spray-guns on the coaches themselves.

PAINTING COACHES WITH A SPRAY-GUN.

Aspect of the problem. Review of the previous position.

The Landy Shops are mainly concerned with the general maintenance of the metal suburban coaches of the Nord Region.

These were painted, both inside and outside, by brush. The number of coats (apart from degreasing, puttying, rubbing down, lettering, etc.) in the case of these coaches (outside painting) was :

— a priming coat (to key to the metal);

— five undercoats;

— a coat of off-colour;

— two finishing coats of lacquer.

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[1] See *Revue Générale des Chemins de fer* for February 1951 (p. 76), July 1951 (p. 347), January 1952 (p. 26) and January 1954 (p. 27).

During recent years, when considering the layout of the new shop and in order to obtain sufficient experience, trials of paint spraying have been carried out at Landy. These trials have made it possible to decide upon the processes to be adopted and have shown the value of setting up a definite installation making it possible generalise the use of pneumatic painting.

STUDY OF THE ORGANISATION OF THE WORK.

A. Investigation into the simplification of painting operations for the interior of the coaches.

1. — *Modification of the interior linings.*

The painting of the interior of the coaches was the hardest problem to solve owing to the ventilation required and the masking needed with the two different colours used. As a result, everything possible was done to reduce the amount of painting that had to be carried out in the coach itself, and to paint the maximum number of separate parts in the adjoining shop. This involved making certain modifications to the sheeting used for inside linings which now had to be assembled already painted. At the same time, the interchangeability and mass production of these parts was made possible, which resulted in a considerable reduction in their cost.

The problem then was merely the painting of the actual body with its inside partitions, but without any of the interior linings.

2. — *Applying all the coats of paint with a spray-gun.*

Preliminary tests showed that it was possible to apply all the coats of paint, including the keying undercoat by spraying so long as the surface to be covered was clean and there was no humidity in the air used for spraying. The Landy Shops for some years have been using a deoxydation-phosphatation chemical treatment on their coach bodies. When the surfaces have been prepared in this way, the coats of paint that are sprayed on adhere well and the paint stands up well in service. It therefore appeared that it would be possible to spray on all the coats and undercoats. Only those parts very subject to oxydation, and therefore not clean (inside surfaces of the body under the side lights) are still painted by brush.

3. — *Doing away the off-colour coats.*

Trials of applying the lacquers direct on the undercoats proved that it was possible to do away with the off-colour coat, as the better covering power of the spray-gun hides the dark streaks which the off-colour coat is intended to mask without leaving any traces on the surface.

4. — *Use of a new technique : hot painting.*

This process, perfected a few years ago by specialist firms, consists in getting the paint to the desired viscosity by heating it instead of adding any thinners and putting it on the surface to be covered whilst it is still hot. The content of useful solids is increased (in the proportion of about 20 to 30 %) (1) and the quantity put on in one coat is increased. The number of coats needed is therefore reduced without any disadvantage. This technique makes it possible to reduce the number of coats on the outside from five to three and to replace the two coats of lacquer with a drying interval between them by one masking coat and another coat applied « wet upon wet ».

The effect of heating the paint is also to reduce the time it takes to dry, the

(1) See *Pigments, Peintures, Vernis,* December 1952.

quantity of thinner being smaller and evaporation in the nozzle during spraying being increased. There is less risk of uneven colour, as the film of paint stretches and rounds off better.

B. Preliminary study of the working site.

To decide upon :

— the profitability of the installation,

— the characteristics of the working sites,

— the basic « hand-machine » times relating to the application of paint with different products (priming, undercoats, lacquers, masking coat or as a coat, on large areas or narrow bands, etc.).

Studies of the different phases in applying the paint, to the outside and inside of coaches, were then established with this dossier and made it possible to determine the speed with which the work should advance in the shop. The theoretical speeds thus obtained by calculation

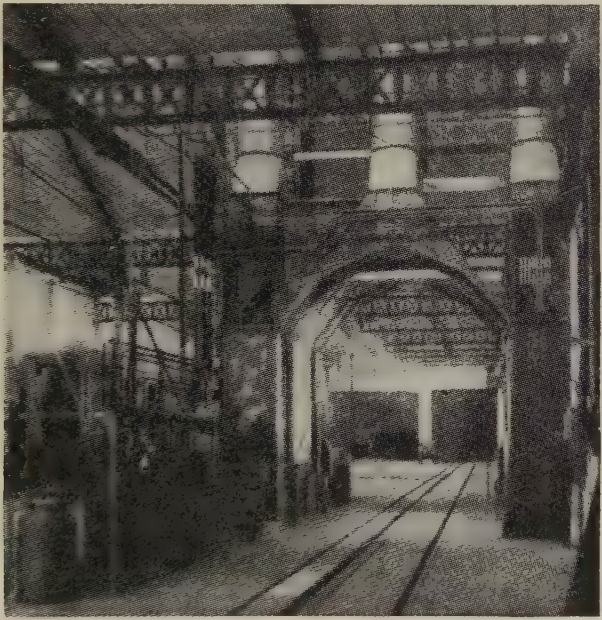


Fig. 1. — General view of the cabin.

it was necessary to make a thorough study of the time taken to do the work, before any changes were made.

This study, carried out according to the basic time study method, meant first of all compiling the dossier of the spray-gun, a document which includes :

— the basic « hand » times established by means of the Standard tables of the QSK movement;

were reduced to three so as not to lead to prohibitive complications in the tool equipment. The width of the working area fixed in the same way as a function of these speeds, taking the laws of ventilation into account.

These preliminary time studies made it possible to get some idea of the time to be allowed for carrying out the work with the installation proposed and to calculate

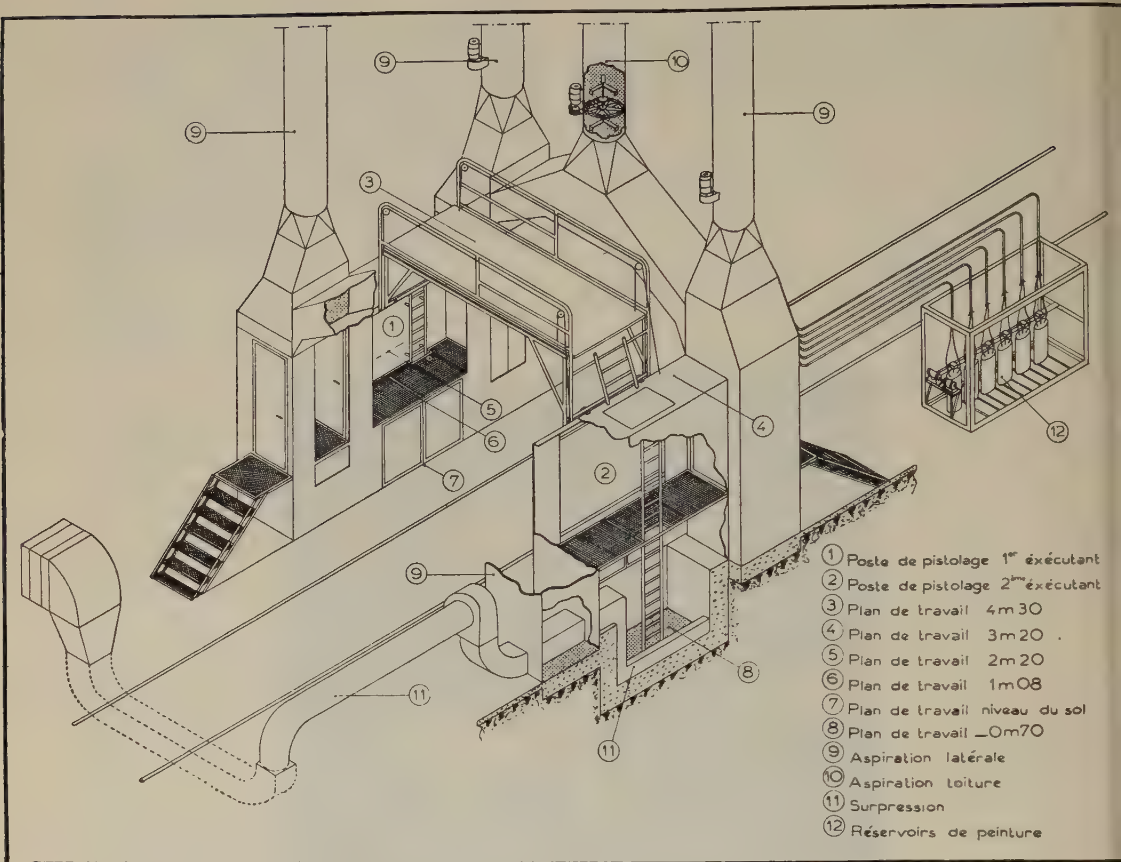


Fig. 2. — Diagram of the cabin.

Legend:

1. Spraying post — first painter.
2. Spraying post — second painter.
3. Work level 4.30 m.
4. Work level 3.20 m.
5. Work level 2.20 m.
6. Work level 1.08 m.
7. Work level at ground level.
8. Work level 0.70 m below ground level.
9. Lateral aspiration.
10. Traction through the roof.
11. Pressure raiser.
12. Paint tanks.

the sinking fund for the capital cost involved.

* * *

DESCRIPTION OF THE INSTALLATION.

The installation includes :

— the painting shop properly so-called. The general idea is taken from the paint shops of the Swedish Malmoe and Orebro Railways. The investigations were carried out by the Installation and Tool Section of the Nord Region, the work being carried out by the Laon Depot;

— the arrangements for moving on the coaches, also studied by the Installation and Tool Section;

— the equipment for distributing, re-

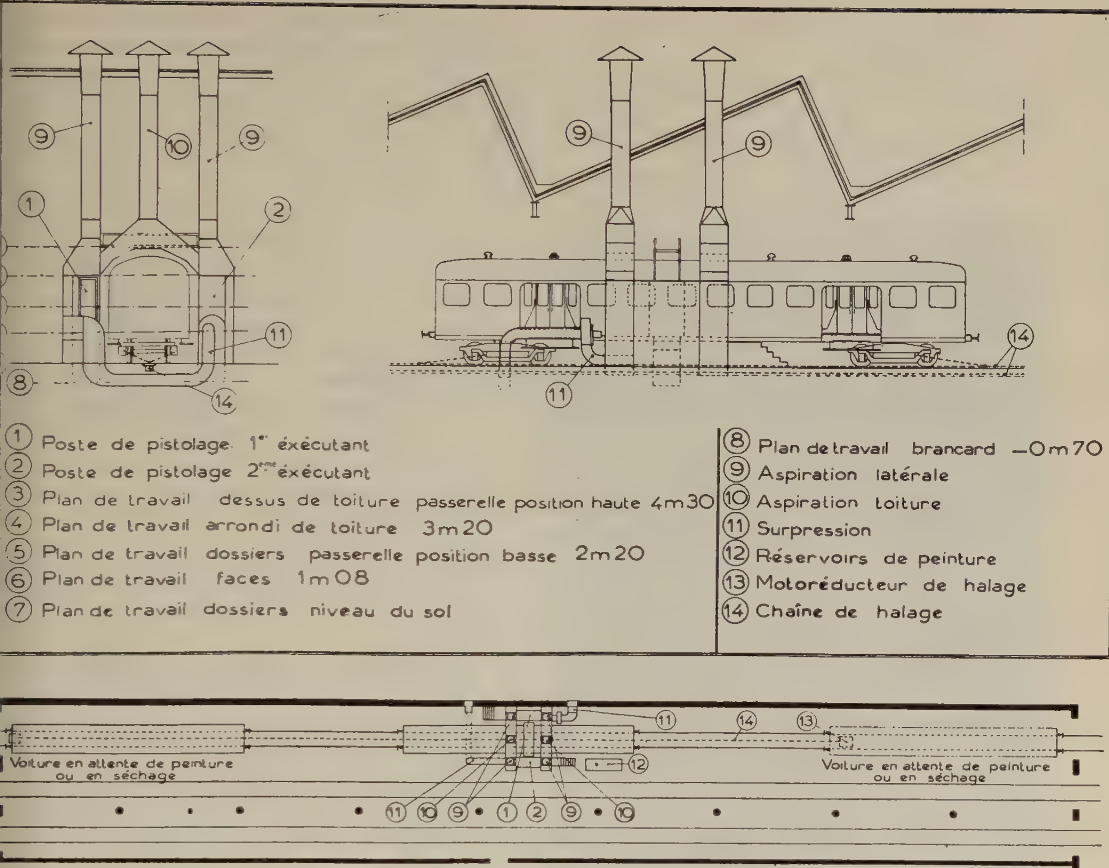


Fig. 3. — Diagram of the shop as a whole.

Legend:

1. Spraying post — first painter.
2. Spraying post — second painter.
3. Work level — the roof — gangway in the high position 4.30 m.
4. Work level — top of part of roof 3.20 m gangway.
5. Work level — backs — gangway in low position 2.20 m.
6. Work level — sides — 1.08 m.
7. Work level — ends — ground level.
8. Work level — underframe — 0.70 m.
9. Lateral evacuation of fumes.
10. Extraction through the roof.
11. Pressure raiser.
12. Paint containers.
13. Haulage motor reduction gear.
14. Haulage chain.

N. B. — Voiture... séchage = coach waiting to be painted or drying off.

heating and spraying the paints. This installation was given to French private firms.

1. — *Paint shop.*

This consists of a tunnel through which the coach to be painted is moved.

On each side, facing the coach, there is a working post consisting of a cabin 2.40 m × 1 m (7.87 × 3.28 ft.) with an opening through which the spraying is done.

Each post has three working levels :

— a pit 0.70 m (2.29 ft.) deep for painting the underframe sills and notice plates;

— a floor at 1.08 m (3.3 ft.) for painting the sides;

— a floor at 3.20 m (10.46 ft.) for painting the rounded part of the roof.

There is also a mobile gangway making it possible :

— in the raised position (4.30 m [13.77 ft.]) to paint the roofs;

— in the low position (2.20 m [7.21 ft.]) to paint the upper parts of the ends (fig. 4).

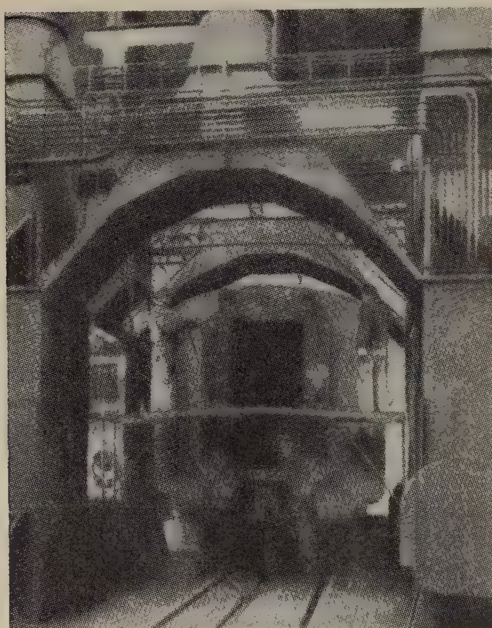


Fig. 4. — Painting an end.

The operators are at ground level when painting the lower parts of the ends.

Ventilation is assured by means of :

a) raising the pressure in each cabin by a centrifugal fan drawing in outside air over a filter and heating battery, and keeping the place at the correct temperature;

b) drawing off the paint mist through vertical grills arranged each side of the working place fitted with helicoidal fans which create a wire drawing of the air in the neighbourhood of the spraying;

c) extraction by aspiration through two hoods, also fitted with helicoidal fans, sited above the roof of the vehicle covering its whole width.

2. — *Haulage arrangements.*

This assures the bringing in and taking out of the coaches before or after they are painted; it also moves the vehicles on under the cabin whilst the painting is being completed.

A three speed motor drives, by means of reduction gear in the pit, an endless chain to which the vehicle is attached.

The scale of speeds is :

— 1.75 m/min (5.74 ft. per min) for painting the surfaces;

— 3.50 m/min (11.48 ft. per min) for painting the roof and rounded part of the roof;

— 7.00 m/min (22.96 ft. per min) for painting the sills and positioning the empty coach.

Press button switches are arranged conveniently to hand at the different working positions. An interlocking arrangement prevents the coach being moved until both operators have agreed to it.

This haulage device serves :

— the actual painting area (a vehicle length on each side of the cabin);

— a waiting and drying post at each end.

3. — *Equipment for spraying the paint.*

This includes :

a) outside the cabin : a collection of eight containers under pressure for the different products used (thinners, primers, undercoats, lacquers). Each container is allocated to a given product and is linked by pipe to each working post. The installation is completed by a small mechanical mixer, and simple gear for handling the tanks;

b) in the cabin, at each working position (fig. 5) : a table where the paint lines are grouped together (one line for each shade), compressed air, paint remover, as also the pressure regulators and paint reheaters.

The compressed air supplying the guns passes through a reheater consisting of two 1 400 W resistances which raise the temperature from 150° to 180° C, then an air-paint temperature exchanger. The paint which is at about 90° C, when it leaves the exchanger, is sprayed at about 70° C from the gun, with a 7 m (22.96 ft.) flexible pipe. These temperatures are regulated by thermostat.

The painters can regulate the air pressure at the paint containers from their working positions as well as the spraying pressure. Finally a cleaning device makes it possible to draw back the paint to the tanks and rinse the pipelines with paint remover.

The whole of the installation is completed by an automatic fire protection system. Suitably arranged fuses if caused to melt by the heat flood the whole of the cabin with a spray of water; the spraying nozzles are distributed at the extractor openings and the working places. Emergency exits enable the staff to get out very quickly.

* * *

Process of applying a coat of paint.

Outside painting :

a) first pass through : painting the top of the roof; speed : 3.50 m/min; painters on the gangway; height : 4.30 m;

b) second pass : painting the rounded parts of the roof; speed : 3.50 m/min; painters on the floor at 3.20 m;

c) painting of the first end; coach at a standstill; painters on gangway at 2.20 m and at ground level;

d) third pass : painting the side; speed : 1.75 m/min; painters on the floor at 1.08 m;

e) painting of the second end; coach at a standstill; painters on the gangway at 2.20 m and at ground level;

f) fourth pass : painting the underframe; speed : 7 m/min; painters in the pit 0.70 m below ground level.

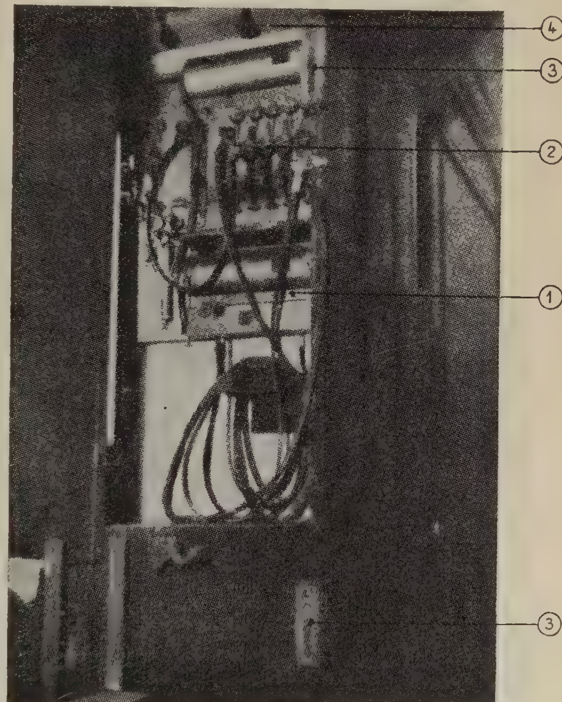


Fig. 5. — Working post.

Note. — *(1) the paint reheater; (2) the entry lines for the paints with their pressure gauges and regulators; (3) the haulage control buttons and (4) the spray nozzles for fire protection.*

Interior painting :

The coach is moved on at short intervals, so that the bays come in front of the extractor openings each time.

* * *

Choice of paint.

The installation has been in work since December 1954 and is now able to deal with the external and internal painting of coaches undergoing general overhauls and the external painting of coaches undergoing intermediate repairs.

The present trial period is being used to determine, in conjunction with the suppliers, the exact characteristics of the glycerophtalic paints to be used in the hot spraying cabin. In particular it is necessary to determine :

— the viscosity when cold (ambiant temperature : 20° C), which will spray satisfactorily at 70° C;

— the correct pressure and temperature of both the air and the paint.

These factors differ for each kind of product and each brand of paint. We are endeavouring to reduce the parameters in order to stabilize working conditions.

* * *

RESULTS.

When these trials are completed, it will be possible to estimate the gain more definitely. It is however already certain that there is :

— a small saving in materials. In spite of the reduction in the number of coats, the thickness of the paint is approximately the same; spraying also results in unavoidable losses in mist;

— a very considerable saving in labour;

— an appreciable reduction in the time coaches are out of service whilst being painted.

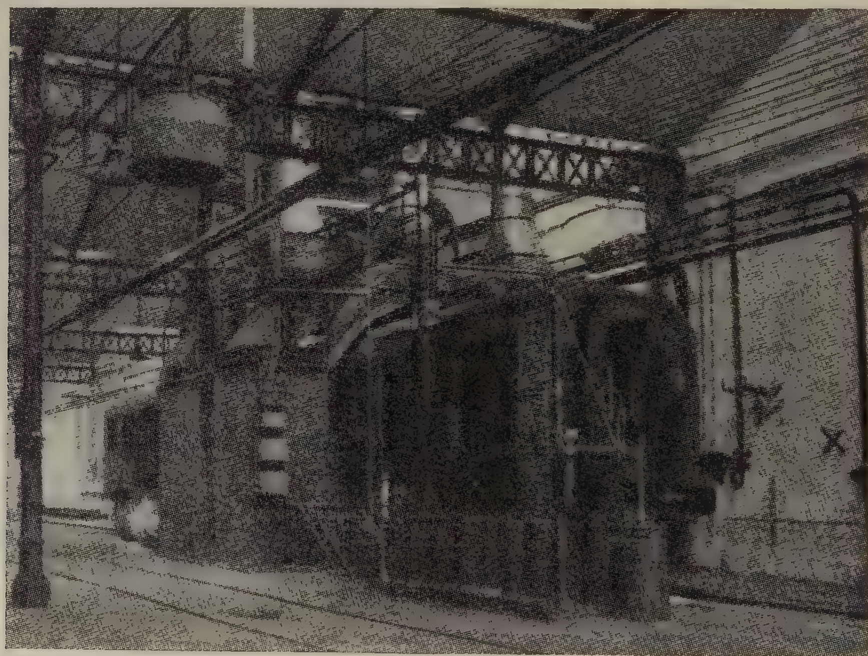


Fig. 6. — The cabin whilst work is in process.

[**625** .144 .1 (73) & **625** .144 .4 (73)]

How to lay rails 1 440 ft. long.

Techniques developed on Santa Fe make this task seem easy—Both standard and special equipment is used.

(*Railway Age*, January 16, 1956.)

During the two years just past, the Santa Fe has laid 142 track-miles of continuous-welded rail. In 1956 it plans to lay an additional 250 track-miles of this rail. The road has, therefore, given much study to how best to handle this rail from the time it leaves the welding set-up until it has reached its ultimate destination in track. As a result of these studies, and of practical experience gained in the field, the road

Fig. 1. — Welded rail from production line is pushed directly onto a string of specially equipped flat cars. There it is supported and « pigeonholed » on an assembly of roller-bearing rollers mounted, one to a car, behind one of the car's trucks. An adjustable threader, on dummy flat car in background, aids in properly alining rail as it is loaded.

has developed techniques of handling, hauling and laying that are giving highly satisfactory results.

The Santa Fe uses both the oxyacetylene pressure-welding and the Matisa-Schlatter flash butt-welding processes (« Railway Age », June 6, 1955) for fabricating continuous rails into lengths of 1 440 ft. This article tells how these long pieces are transported and laid, beginning as the rails come from the production line.

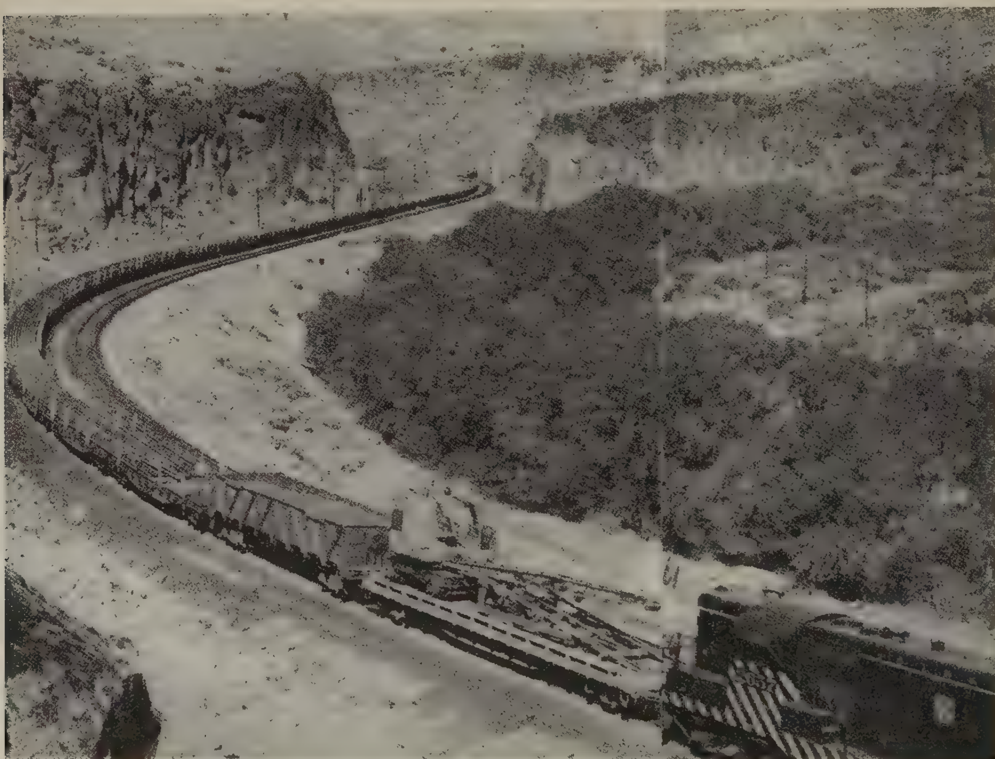


Fig. 2. — Rail en route easily adapts itself to track curvature. Here a train load of 12 rails, is snaking around curves on way to unloading site. Rail is anchored on only one car at middle of train, thus, any movement of the rail due to train action or track curvature is compensated by movement of the rail ends. Train consists of 31 cars.

Loading techniques.

Leaving the welding line, and propelled by the winches which move them from station to station along that line, the rails pass over a dummy flat car spotted between the end of the production line and the rail train. The train consists of 31 specially equipped flat cars, having a capacity of 12 strings of the long rails. The dummy flat car is equipped with an adjustable threading device which can be moved across the car as desired to guide the rails into their proper « pigeonholes » on the rail train. The head end of each rail is fitted with a special temporary shoe which prevents it from digging into the deck of the car as it moves along.

Each specially equipped flat car of the rail train is fitted with a single assembly

of 12 special roller-bearing rollers, mounted on a single shaft, which supports the rails during transportation. Rollers in the assembly are separated from each other by vertical steel plates edgewelded to the flat side of another steel plate attached to the deck of the car. These plates form the series of clamping plates which bear on the tops of the rails. This method of anchorage permits the free ends of the rails to move under the effect of varying conditions of temperature and operation. A car of ballast is placed in the train at either end of the string of rail cars. These

Fig. 3. — Walkie-Talkie set aids in maintaining constant communication with the locomotive engineer during unloading operations, eliminating need for hand signals. This crew member is stationed on the rear car.

pigeonholes in which the rails are placed. A man with a bar guides the shoe at the end of each rail as it reaches the rollers to insure that the rail enters the proper compartment.

During transportation, the rails are anchored on only one car near the center of the train. Anchorage is provided by a serve as safety buffers in case operating emergencies should result in longitudinal shifting of the rails. A crane is usually hauled on a flat car immediately behind the locomotive so it will be available during unloading operations. This crane car is set out at the closest siding to the unloading site. There the crane is unloaded with

the help of a ramp which is carried on the car.

Radio controls unloading.

The locomotive and caboose of the work train are equipped with railroad radio. A member of the train crew equipped with a « walkie-talkie » set is stationed on the rear car of the rail train during unloading operations. This man maintains constant communication with the locomotive engineer. The need for hand signals is thus eliminated and the unloading of rail is expedited even under the most adverse operating conditions.

Rails are unloaded two strings at a time. The crane which accompanied the work train makes the first pull necessary to land the ends of the rails on the ground. As the train pulls ahead and out from under the rails the crane maintains its pull until sufficient rail has been landed on the ground to resist the pull of the train. Each succeeding rail is attached to the preceding one by fish plates and is pulled off the train in sequence.

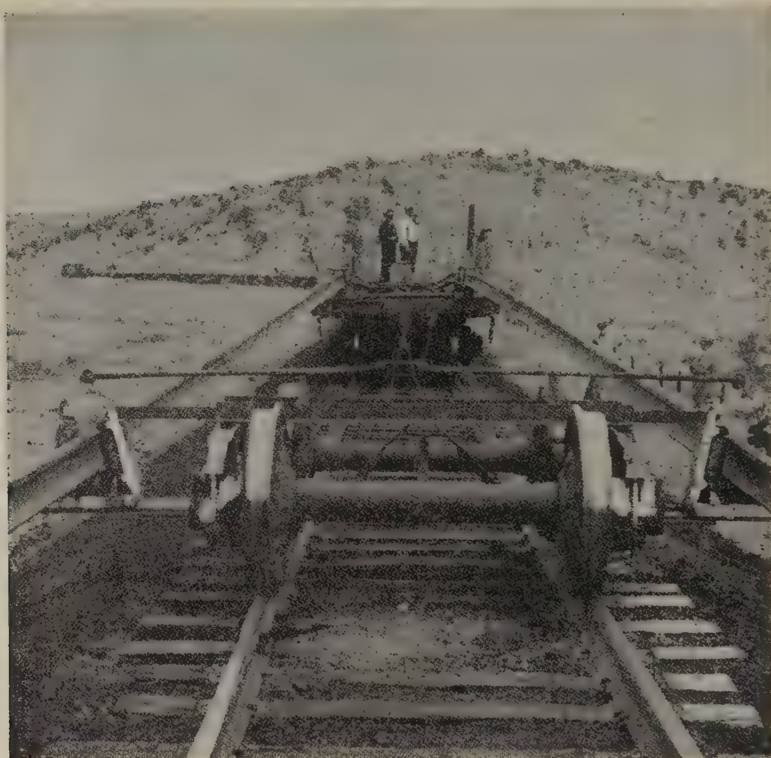


Fig. 4. — Two rails are unloaded simultaneously. Threaders mounted on either corner of the last rail car and on a « caisson », towed about 50 ft behind the rail cars, guide rails to the ground at toe of ballast shoulder or in center of intertrack space.

As rails leave the train they pass through

threaders mounted on each corner of the end car. They then run through threaders mounted on outrigger frames carried on a be set to maintain sufficient drag to prevent it from « running up » on the rail cars when it is in use.

Fig. 5. — Threader suspended from the boom of Burro crane or Speed Swing is used to move rail into center of track prior to laying. The use of this device, which slides along the rail, makes it unnecessary to hook and unhook rail tongs.

« caisson » which is towed by cable about 50 ft behind the last rail car. The caisson is made from an old freight-car truck and is equipped with a handbrake which can

The outriggers are adjustable so that the threaders can be set 6 to 7 ft on each side of the center of the track.

Use of the threaders on the caisson make

it possible to drop the rail at the toe of the ballast shoulder or in the center of the intertrack space as it is being unloaded.

Fig. 6. — Crane moves down track while shifting rail to the center. Two men with bars follow crane to steady rail and keep it erect. These men also line out any irregularities in the position of this rail which might interfere with operation of machines during rail laying.

In these locations, it is out of the way until required in the rail-laying operation.

The Santa Fe makes no effort to tailor its long rails to fit physical conditions in the field. Whenever conditions require installation of an insulated joint or a switch, the welded rail is cut to fit in the field. A short piece of rail is cut-in on either side of each insulated joint. This permits repairs and adjustments to be made at these points without disturbing the

welded rail. Turnouts are installed either before or after welded rail is laid as conditions demand.

Fig. 7. — Spikes are pulled by a pair of Nordberg mechanical spike pullers each machine pulling spikes from every other tie. Joint bars are then knocked off, rail is barred out, scrap is thrown out of the track zone and tie plugs are set and driven.

At farm or unpaved crossings trenches are made through the crossings to receive the rail as it is unloaded. After the rail has been placed in them the trenches are filled in to restore the crossing. At paved crossings, the welded rail is dropped and then pulled back clear of the crossing if the end of the string falls within 5 or 10 standard rail lengths of the crossing. Otherwise, the rail is flame cut at a location outside the crossing and is then pulled back to clear the highway. Before these cut ends are rejoined with standard joint

bars during the rail-laying operation, the portions of the rail ends affected by the heat of cutting are sawed off.

the same types of machines that are employed in laying standard-length rails. The gangs vary only in the distribution of men

Fig. 8. — Cribbing machines remove high ballast from rail zone in cribs between the ties. Two types of these machines are used, the Kershaw Kribber (shown here) and the Nordberg Ballast Router. Two men equipped with hoe and broom follow closely behind to clean ties.

Fig. 9. — Ties are adzed behind the cribbing operation. — Three Nordberg adzers operate as a team to smooth the ties and provide a solid surface to receive the tie plates. Before the plates are distributed, however the adzed surfaces of the ties are sealed with a coat of...

Rail laying highly mechanized.

During the 1955 working season, when the road laid 103 track-miles of continuous rail, several extra gangs of approximately 100 men each were utilized for this purpose. This work is highly mechanized with used in carrying out some of the manual operations.

When the steel gang arrives on the ground the first operation is the removal of rail anchors, bond wires, crossing planking and motor-car set-offs throughout the distance where rail is to be renewed. A

Fig. 10. — ... hot creosote spread by a Fairmont tie sprayer. This machine trips automatically at each tie as it is pushed along.

Fig. 11. — Plate-lining machine or pre-gager built by the Santa Fe positions plates and distributes the anchor studs used in the gaging operation. The tie plates are placed on the ties in advance of this machine by a gang of five men that follow closely behind the tie sprayer.

Fig. 12. — Gaging is done with a Dun-Rite gaging machine. This machine accurately positions tie plates so that when rail is placed between the shoulders of plates the head-to-head gage is correct. Holes are drilled through anchor holes of the plate on every fifth tie as the machine moves along to receive...

Fig. 13. — ... racor studs which are driven through these holes and anchor the tie plates in position. The track is now ready to receive the welded rail which is moved from the center of the track into position on the tie plates with the aid of a Burro crane operating on rails or a...

Fig. 14. — ... speed swing which straddles the track while placing rail. Two men following crane distribute spikes while 6 to 8 men behind set and start them.

Fig. 15. — Spike driving is done by two Racor Dual spike drivers which are are air-operated from a track-mounted air compressor. Or spikes may be driven by a 10-man gang equipped with air guns. A gang of 16 men follow spike drivers straightening crooked tie plates, driving missed spikes and distributing and installing rail anchors.

crane then sets the new rail into the center of the track. This operation involves the use of a threader suspended from the boom of the crane. The rail is inserted in the threader and, as the crane backs down the track, it literally pulls the rail into the center of the track. The remaining steps involved in laying the long rails are shown in the illustrations.

The long rails are anchored by « boxing » every other tie. Standard joint bars are applied to connect the long lengths of rail. A rail saw accompanies the rail-laying crane and is used to cut the long rails as required at insulated joints and elsewhere. A rail drill is used to make the necessary bolt holes where rail has been sawn in the field.

Generally the track in which rail is to be renewed is raised out of face and the ties renewed in advance of the rail-renewal operation. After the new rail has been placed a Jackson Track Maintainer spots up the loose ties and completes the operation.

[625 .13 (492)

Reconstruction of Moerdijk bridge, Netherlands Railways.

Carefully planned and executed work over 1 km long.

(*The Railway Gazette*, April 20, 1956).

The most important north-south line of the Netherlands Railways, connecting Amsterdam, The Hague, and Rotterdam with the South of the country, also Antwerp, Brussels, and Paris, crosses the Hollandsche Diep estuary at Moerdijk, between Dordrecht and Lage Zwaluwe, the natural width of the channel at this point being pratically a mile. On January 1, 1872, the original bridge across it was opened for traffic; it was some 4 950 ft. in length and consisted of 14 through truss spans with curved top chords, carrying a single line of railway, and was considerably the longest railway bridge in Holland.

One of the 680-ft. continuous two-span sections being assembled in the artificial five-acre basin.

During the last year of the second world war, the retreating Germans destroyed or rendered useless six of the spans and three of the piers. Fifteen months after the German surrender the bridge had been temporarily repaired by the use of eight of the original and four new makeshift spans; the remaining spans near the north bank of the Diep were replaced by an embankment and two temporary piers were built.

Limited traffic working was thus restored, but this single-line bottleneck and the fact that the steel in the spans was suffering from fatigue made it imperative to provide a new double-line bridge up to modern

An old span on falsework and lighters being floated away to make room for a new one.

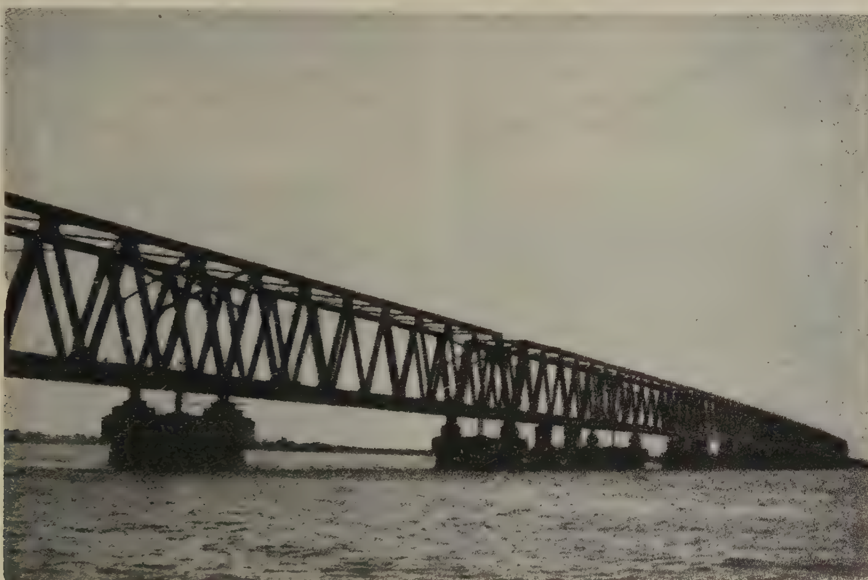
A new span on lighter; supported staging being floated into position over the piers.

standards of loading at the earliest possible moment, to meet the growing traffic on this important trunk line.

As it was found that the existing piers could be adapted to carry new double-line spans, the new bridge was erected on the original alignment. However, this entailed most careful design and detail planning, and each new span had to be substituted for an old one under traffic with a maximum line-block of 12 hr on pre-determined Sundays, selected to suit the tides and other conditions.

The new superstructure consists of one 98-ft. plate-girder span and five through parallel-chord truss sections, each about 680 ft. in length but designed to form two 328-ft. continuous spans with a central pier; the trusses consist of Warren girders without verticals. The various steel sections required were rolled in mills in Holland, Germany, Belgium, Luxembourg, and France, and fabrication was organised in Dutch factories as large units. All the materials were tested both chemically and mechanically, and the units were sand-blasted and given one coat of red-lead paint before despatch to the assembly points.

This and subsequent works were planned in accordance with exacting time-schedules, enabling each two-span 680-ft. section to be completed in four months. To make room for subsequent units to be received for assembly, each two-span section had to be shipped immediately it was completed, and the rolling mills and fabricating factories had in turn to work to a co-ordinated timetable to ensure continuous progress throughout.



Simplicity of the continuous Warren truss design.

Assembly of superstructure.

Three two-span sections were assembled by one contractor in a five-acre basin specially excavated for the purpose, and the two other sections were assembled by another firm at Dordrecht and floated down to this basin. There, each two-span section was erected complete and then divided again into two halves for final floating to site.

The most important timetables, however, were those drawn up for the « shipping Sundays » when this floating out and erection on the piers were carried out. Along the route followed many preparations had to be made. Because of the uncertainty of the weather, reliance had to be placed on forecasts, and reserve-days had to be allowed for on the Tuesdays and Wednesdays after shipping Sundays in case postponement was necessary.

The spans fabricated at Dordrecht were floated down to Moerdijk on the Saturdays before shipping Sundays, and had to pass under a road bridge and a railway bridge at Dordrecht and also a second railway bridge at Baanhoek. Between the floating bridge-sections and the piers of the first railway bridge there was a clearance of only 4 in. on each side, and at the second one a span had to be removed. The whole of this operation had to be completed within 3 hr.

On shipping Sundays each old span was jacked up to the height required by the tides and weather report; the maximum wind velocity allowed for was 16-18 m.p.h. At low tide lighters, flooded with water, were towed and warped under the span, and, as high tide approached, they had the water pumped out of them, thus lifting the span off its bearings, and enabling them to float it away. Meanwhile a new span-length was ready at hand and was floated in just before high tide. By flooding the lighters under it and on the falling tide the new span was lowered on to its new bearings on the old piers. This, together with preliminary and subsequent track and other essential works on the span, had to be completed within the 12-hr line-block. During this period local traffic was maintained by bus services and through traffic was diverted via 's Hertogenbosch and Utrecht.

On only one occasion was there imminent danger on a shipping Sunday, when warning of an approaching gale was not received in time, due to a broken telephone cable. Fierce gusts of wind snapped all the steel warping, towing and mooring cables except two small ones which fortunately held safely.

Eventually the whole work was completed a week ahead of the 18 months' schedule, enabling changes in the train service to be tested before the winter timetable came into force. Though the new structure is nearly 1 450 ft. shorter than its predecessor, it is still the longest railway bridge in Holland, and its construction in so short a time was possible only because of the care with which all stages of the work were planned and executed.

We are indebted to the President of the Netherlands Railways for the information contained in this article and for the photographs reproduced.

[656 .212 .8 (73)]

Electronics improves « in motion » weighing.

New electronic scale, service tested at the EJ & E's Kirk Yard, keeps pace with push-button classification,

(*Modern Railroads*, April 1956.)

The new push-button type retarder yards have created a need for faster automatic weighing systems. Accuracy in weighing cars in motion is still a first essential. But to keep pace with « movement » in the newer yards there also must be fast response to weight. The weighing system, moreover, should be adaptable to various data handling and processing systems being developed for « automated » yards.

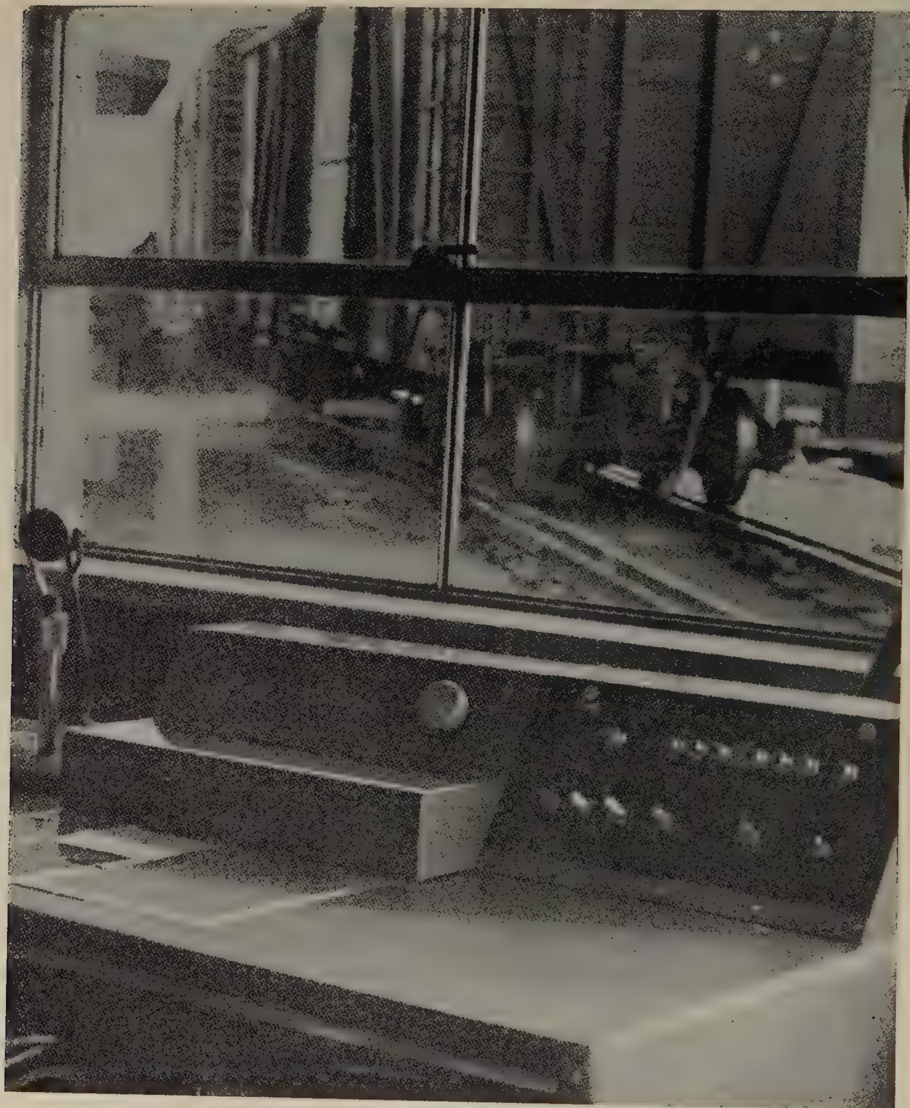
A new electronic system recently developed to perform in this way, has been at work at the Elgin, Joliet & Eastern's Kirk Yard in Gary, Ind. Its forerunner is the Ametron line of industrial scales and recorders made for some years by Streeter-Amet Co. of Chicago, manufacturer of the new electronic « in motion » scale.

At Kirk Yard the scale has weighed up to six cars per minute with the three second print timing used in that setup.

As one car enters master retarder at Kirk Yard another leaves the new electronic motion weighing scale. Others follow for weighing.

In tests run with the equipment over a period of months a large majority of the cars were considerably within the applicable tolerance for motion weights, which is plus or minus 0.2 % of gross load plus one-half graduation down to the minimum graduation (in this case, 100 lb).

Kirk Yard is a modern gravity type classification yard equipped with General



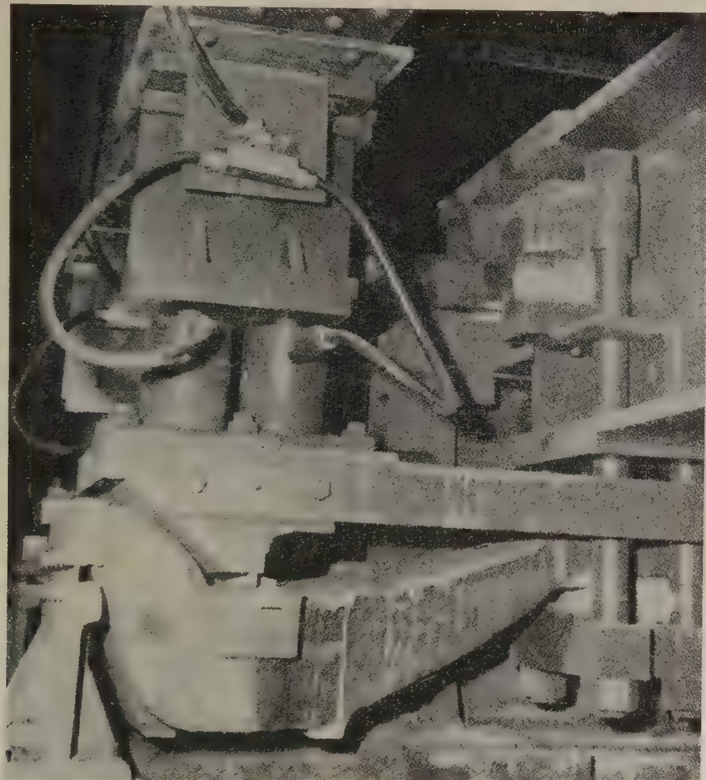
Weighmaster's view as cars enter scale. His controls and instruments are on special desk. The car shown here is on the dead rail.

Railway Signal Company's Yard Automation System, employing automatic switching, radar speed measurement, and electronically computed retarder controls. The scale is installed 50 ft from the crest of the hump. Cars to be weighed are switched over a rail entirely supported, for 92 ft by the scale. Car weight is recorded while cars travel at from 4 to 12 miles per hour. Cuts humped with no weighers in

them are run over a dead rail directly adjacent to the scale rail. The Kirk Yard installation is of a dual nature; a completely independent lever system and mechanical weight recorder provides a ready check of the electrical system's performance on both static and motion weights.

counters are located at each end of the scale.

To weigh a car, the operator or weighmaster sitting at the desk depresses a zero switch located on the control panel at some time prior to the car entering the scale. He then « zeroes » the scale with no load on it by means of the zero adjust knob and prints 0000 by depressing the print switch. The counting circuits are then put in cycle, if necessary, by momentarily depressing the cycle switch. When in cycle, a green light will show.



Sixteen 100 000 lb capacity load cells support the weighbridge at eight points. Shown is the arrangement of load cells and plate fulcrum main levers under two support points at center of scale.

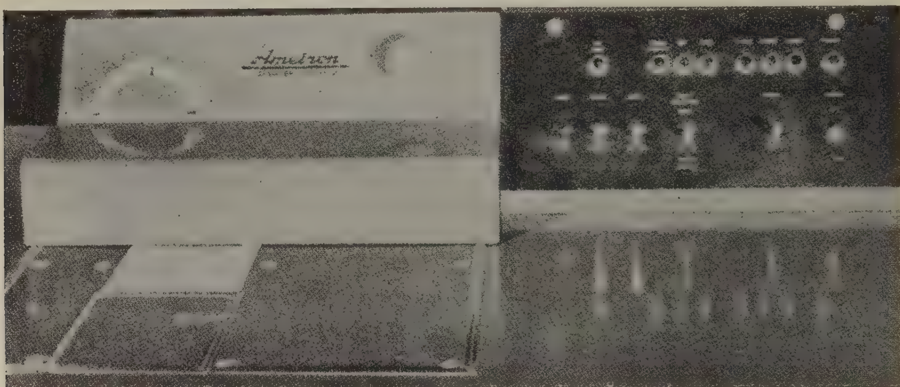
The new scale consists essentially of three elements : (1) strain gage load cells entirely support the weighbridge to which the live rails are fastened; (2) a self balancing servo system, printer and a counting and cycling mechanism are completely built into an operator desk located in the scale house; and (3) two solenoid operated trips or wheel

As the car to be weighed approaches the scale the weighmaster operates the

wheel count selector switch. It energizes the solenoid operated wheel counters bringing them to the « up » position where they will be depressed by car wheel flanges moving over them. It also enables the servo system to respond to loads on the scale. Finally, it turns a light from red to green, signifying to the operator that the next car to come on the scale will be weighed.

of cars, another zero print is obtained and the tape is removed.

Here is what this weighing system includes : Sixteen 100 000 lb capacity load cells support the weighbridge at eight points. They consist of four strain gages in a wheatstone bridge circuit with two legs of the bridge active to loads applied vertically to the machined column on which the gages are affixed. Resistors



Closeup of operator's control panel. He has control switches. Lights signal various operations. The car weights are automatically recorded on a 5-in. wide paper tape. The weighmaster then records other necessary information.

The cars to be weighed then pass across the scale singly at speeds from 4 to 12 m.p.h. The weights are automatically recorded on a 5-in. wide paper tape after the cars have been on the scale for three seconds. The weighmaster then records other necessary information such as car initials and number, empty weight and capacity of the car. The unit sets itself up for the next car, and continues weighing each car until the wheel count selector is returned to the « off » position.

For certain extremely long cars, which are not on the scale a full three seconds, the operator can depress a foot switch and cut the weighing time to 2.5 sec; letting up on the switch immediately returns the timing to three seconds. At the completion of all weighing for one particular cut

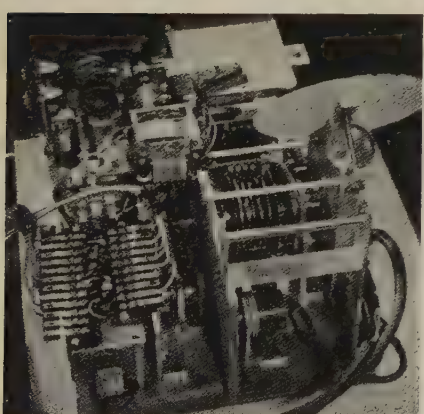
compensate for changes in output due to change in the modulus of the loading column, for change in resistance of the cell excitation leads and bring the cell input resistance to approximately 120 ohms.

Sets of two cells each are excited in parallel from eight secondary windings of a distribution transformer at 5.5 V A.C. In the recorder, the voltage from the cells is compared with two voltages which are opposite in phase to it. One of these voltages is the manually controlled zero voltage which is made to exactly buck out the cell voltage with no load on the scale. The other is the servo-driven balance voltage which is zero after the scale is balanced with no load; but for any other condition it seeks a voltage that will net the three voltages to zero when applied to the input of the servo amplifier.

This net voltage is applied to the amplifying system. After sufficient amplification it drives two 2-phase motors. They in turn position an analog to digital converter and an ultra precision potentiometer picking off the balance voltage.

The analog to digital converter converts the rotary motion of a system of disc cams

All components at control desk are readily accessible to the operator. All units are plug-in assemblies.



Printer unit shows electrical leads. Part of the analog to digital converter is visible at right center.

to digital information in the form of weight by sensing the various positions of the cams. In doing so, it rotates type wheels to the digital equal to the rotational motion of the cams. When the type wheels have been positioned a print hammer strikes them through an inked ribbon and prints the weight on the tape. The tape automatically advances so the operator can make his weight subtraction to determine net weight.

To reduce overall system wear to a minimum and to decrease the necessary response time of the analog to digital cams, two correlated systems are used. Both are actuated by relays in the counting and cycling circuits. The first of these circuits presets the scale to approximately mid travel in the weight range between maximum heavy load and the lightest load.

This point is about 120 000 lb at this site. After the operator has the scale in cycle, it automatically goes to 120 000 lb, waiting for the first wheel of the car to be weighed. Then, as the first axle of the car enters the scale, the relays in the counting circuit effectively multiply the weight so that the machine responds toward a predicted total car weight rather than the weight of a single axle. Simultaneously, the preset 120 000 lb is removed so the unit responds from 120 000 lb to the predicted total car weight. As each axle of the car enters, the prediction of the total weight is corrected until as the last wheel comes on, the multiple is changed to one and the unit settles to the exact car weight.

Prints weights automatically only.

Of the three seconds available after the car is fully on the scale, 1 1/2 sec are allowed through time delay relay circuits for the unit to come into weight in high speed. Then the drive to the cams is shifted to low speed and remains in this condition to dampen any oscillation due to the vibration (sometimes extreme) set up in the weighbridge by the car in motion. After 1 1/2 sec damping the timing relays actuate the print circuit and the weight is registered. Automatic printing is the only method by which the unit will print; the manual print switch is electrically disconnected at all times except when zeroing.

If the car is travelling too fast and is not on the scale the required three or 2 1/2 sec, the counting and cycling unit disallows a print and returns the circuits to « in cycle » waiting for the next car. Similar operation takes place should the operator inadvertently leave the wheel count selector switch in the « on position » with multiple cuts coming over the scale or should a second car enter the scale before the first has been weighed.

The printer unit, including analog to digital converter, is recessed into the desk top just to right of center in front of the operator and is covered by two quickly removable cover panels and a hinged cover on which is located the zero adjust knob.

« Other accessories such as readout to punch tape or cards, telemetering to remote stations, and ticket rather than tape printer are available and readily adaptable to the motion weighing recorder », states J. R. Shepley, Assistant Service Manager of Streeter-Amet Co. « The same basic recorder can be used on any motion weighing scale on grades up to and including 3 %, perhaps more, and can be used for two-draft weighing. »

[621 .431 .72 (73) & 625 .232 (73)]

Standard length, 595-lb per passenger in . . . Budd's bid for lightweight market.

« Pioneer III » has new lightweight trucks, spring system, structure and finish which cut weights and costs, but not riding qualities and safety.

(From the *The Railway Age*, July 23, 1956.)

Weight-per-passenger of 595-lb was achieved in this 85-ft coach with use of special trucks, new structural arrangements, and utilization of new car building materials.

Designed for lower mileage services in which profits are not possible because of the operating and fixed costs of present-day standard equipment, the new Budd lightweight coach weighs 595 lb per passenger seat.

The development was carried on to provide an economical passenger car for commuting and medium distance services. However, the design has been adapted to the car arrangements necessary for long-distance runs. This new Budd « Pioneer » is now being offered as a solution for problems throughout the passenger traffic field.

« Pioneer I » and airplanes were Budd's first ventures in the structural use of stainless steel. « Pioneer II » is the « Pioneer Zephyr », still in service on the Burlington after 22 years. « Pioneer III » was developed to be suitable for general use without a wholesale revolution in railroad operating practices. It has AAR tight-lock couplers at standard coupling height. It also complies with AAR and ICC strength and safety requirements. The Budd position is that the 85-ft car permits the greatest economies in structural materials and construction costs. Shorter bodies, according to Budd, introduce a

weight penalty because of the larger number of car ends.

For riding qualities and safety, this builder has retained the four-wheel truck, although its design has been radically changed and its weight reduced to 6 300 lb. The head end electrical power, which Budd first used on the early Burlington Zephyrs and which has recently been accepted by more and more railroads, was utilized to reduce weight, first cost and operating expenses.

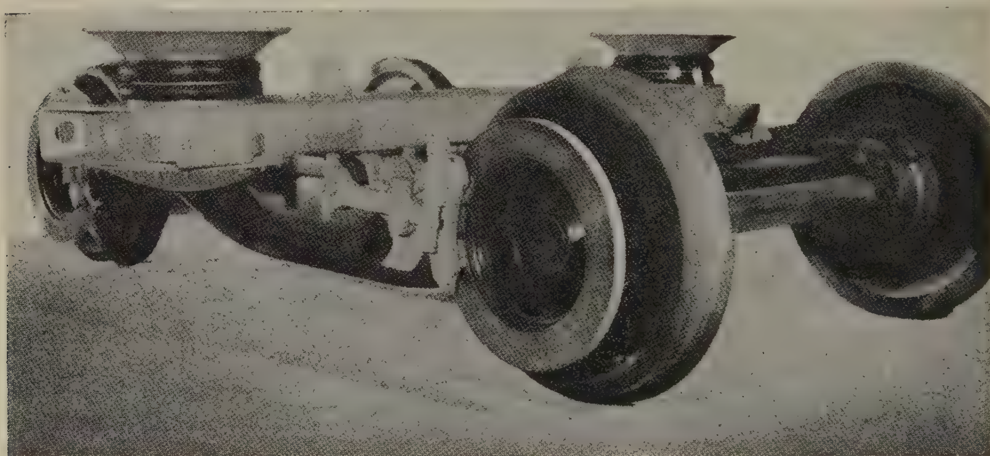
The comparison between a conventional Budd lightweight 74-passenger coach and the new « Pioneer » coach seating 88 shows a weight saving of 70 330 lb. Tabulation of the components produces this comparison :

	« Pioneer »	Conventional
Car body structure	26 005 lb	44 250 lb
Equipment and supports	6 115 lb	26 260 lb
Interior trim and appointments	7 150 lb	14 610 lb
Trucks	13 060 lb	38 100 lb
Weight empty	52 330 lb	123 200 lb
Service load	800 lb	2 500 lb
Weight per passenger	595 lb	1 858 lb

The finished car is not a completely independent unit because of the need for head-end power and because of the « LWE » brake equipment. However, few of the recently built railroad passenger train designs have been governed by requirements of complete interchangeability.

Budd envisions « Pioneer III » as a basic car which can be adapted to a complete line of car types for mainline use. These, with their estimated weights, are :

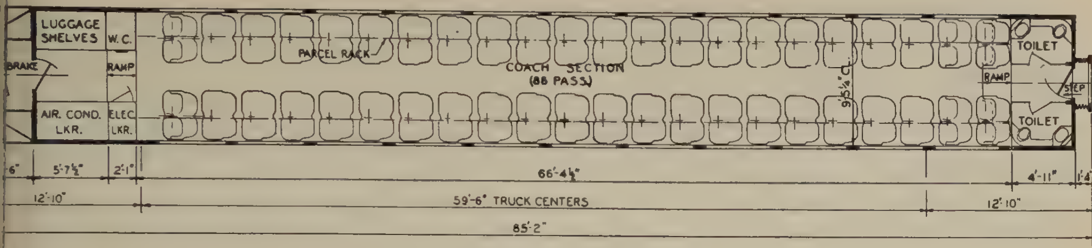
	Lb.
88-passenger interchange coach	61 000
52-passenger coach	62 000
MU car	79 000
Diner	71 500
Bar lounge	69 000
Sleeper	79 000



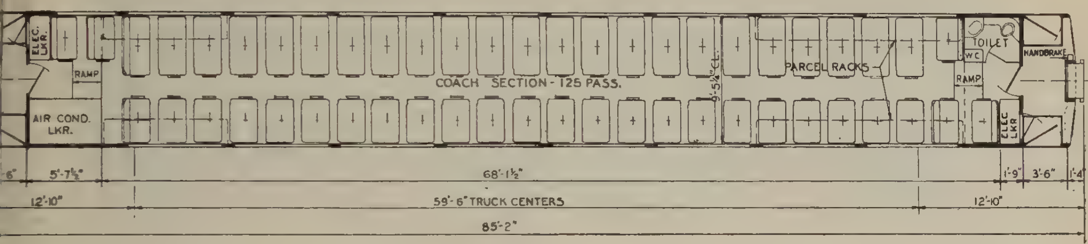
Truck substitutes single air spring on each side for conventional double spring arrangement. Car has tubular axles and outside-mounted disc brakes.

Truck completely new.

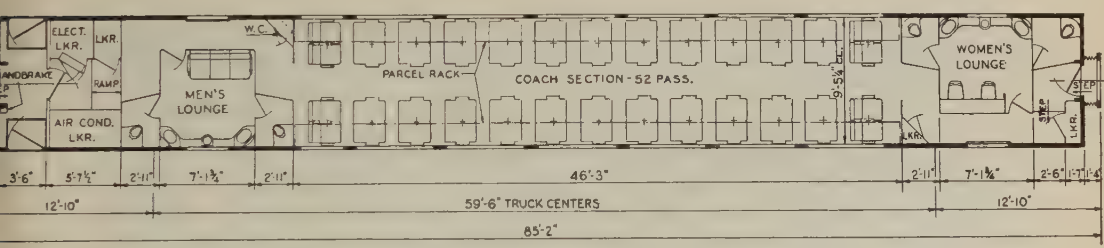
In designing the new truck, the structural goals were to be low weight without sacrifice of strength, or simplicity of fabrication, and to increase ease of maintenance. Dynamically, Budd's aim was to provide a level, safe and quiet ride under all road conditions and loadings. The mechanical design, frequent use of new



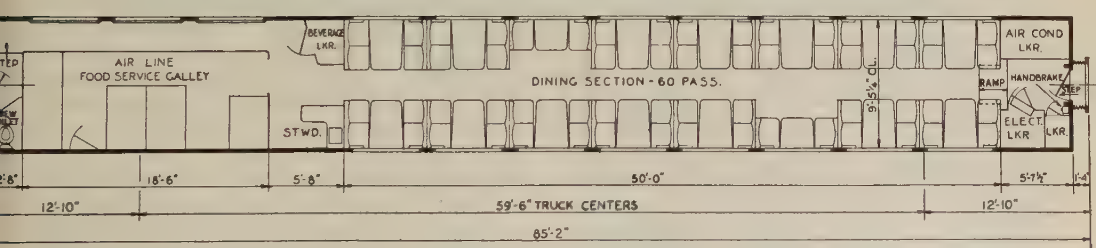
High capacity mainline coach.



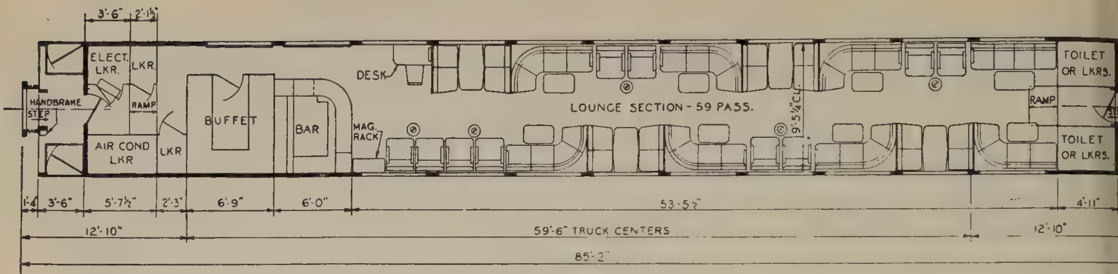
M. U. commuter coach.



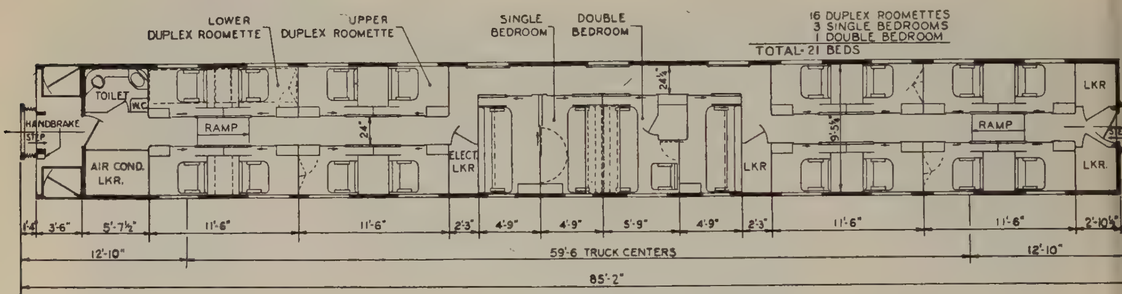
52 pass. mainline coach.



High capacity diner.



Tavern-lounge car.



Sleeper.

materials, and utilization of air spring suspension have been the Budd methods of achieving these aims.

The low truck weight was achieved by making the load paths from the carbody to the wheels as direct as possible to reduce bending moments. The principal parts are two side frames, a truck bolster and two Firestone air springs. Such parts as the equalizer beams and swing hangers are eliminated. Body loads are transmitted by the air springs directly to the truck bolster at a point near the side sills. This makes possible an extremely light car body bolster.

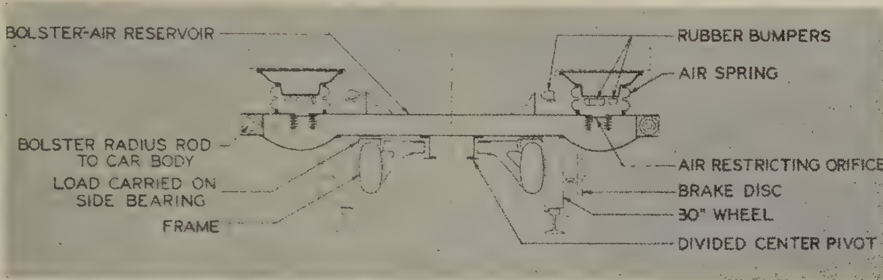
Vertical loads then go from the truck bolster to the side frames through side bearings with non-metallic bearing surfaces. The truck side frame then carries the load directly into the inboard journal bearings. With these inboard bearings, a shorter, lighter axle has been used. The car has 30-in. diameter wrought steel wheels.

The grease-lubricated Timken roller bearings have their inner races mounted on the tubular axle and the outer races carried in rubber bushings clamped in split rings, which are the ends of the side frames. Rubber mounting is to insure uniform bearing loading, and the serrated split arrangement makes it possible to change wheel sets. The side frames are hollow beams of deep, oval cross section assembled from two stampings welded together.

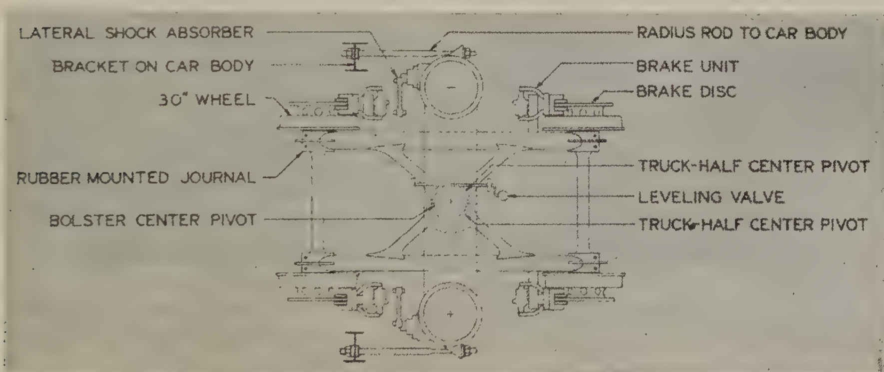
Integral with each side frame is a triangular structure terminating in a half bearing at the central pivot attached to the bolster beam. This allows independent vertical motion of the two side frames to allow the truck to negotiate vertical irregularities in the rail. The truck is maintained in tram by the central pivot which prevents longitudinal displacement of the side frames and resists lateral thrusts while allowing the truck to rotate under the bolster.

The bolster beam is hollow and is used as an air reservoir for the air springs. Rotation of the bolster is prevented by rubber-mounted anchor bars extending to the side sills. These links also transmit braking forces into the car body. Both lateral and vertical bolster movement is possible, but lateral is finally limited by rubber-cushioned bumpers. A new Budd disc brake is mounted outboard of the plastics. These innovations, along with the arrangement of parts, are intended to simplifiy maintenance and reduce costs. In combination with the air springs, the non-metallic mountings isolate the body from external vibration and noise.

The air springs work in conjunction with the reservoir formed by the hollow bolster beam to produce a unique dynamic system. At the bottom of each air spring



Diagrammatic section shows the relationship of the air springs to the bolster which serves as an air reservoir for the springs. The restricting orifice is clearly shown.



Plan view of truck, the principal parts of which are two side frames, a bolster and two Firestone air springs. There are no equalizer beams or swing hangers.

wheel, and both the disc and the operating mechanism can be readily removed.

Metallic wearing surfaces in the truck are completely eliminated and moving parts are isolated by rubber bushings, brake lining material, and wear-resistant is an orifice which opens into the hollow bolster. Produced is a spring with a variable spring rate and built-in damping that varies according to the frequency and displacement of the air springs. The single spring acts as a stiff undamped

spring to cushion jars caused by rail joints and as a soft spring with high damping to smooth out track irregularities.

Analog computer used.

The result was produced after a study using the Analog computer at Franklin Institute which indicated the proper spring volume, reservoir volume and orifice diameter. Tests have shown that the result produces a ride superior to the standard equalized truck with the conventional double spring system such as used under the Budd RDC cars. Because the two air springs are connected through the bolster reservoir, there is considerably less resistance to side lean than in the conventional truck. However, the lower weight of the car, and the smaller moment arm through which this weight acts on the truck, have yielded a car in which lean is less than that of conventional coaches on the same curves.

The same ride is provided under all loadings by holding the static height of the car constant with a leveling valve attached to the center of the bolster and to the body. Changes of air pressure in the spring system are made only with changes in static load because the valve acts only if the center of the normal vertical oscillation changes. This same leveling system is utilized to adjust the cylinder pressure in the brake system and make braking force proportional to car weight. Lateral oscillation is damped with two specially designed Houdaille shock absorbers, and truck shimmy is damped out by friction introduced at the side bearing.

Lighting level and bright interiors should attract passengers, maintenance economies are to appeal to railroads. Lining from floor to air duct is two pieces of plastic.

New body design.

The body is a welded, high-tensile, stainless-steel structure combining standard Budd practices with some used by their European licensees and with a new underframe construction. A divided center sill composed of two stainless Z-shaped members is connected directly to the collision posts at the ends. A lightweight welded alloy draft gear pocket braces the end of the car, carries the draft gear and coupler, and reinforces the joints between the center sills and the collision posts. The widely spaced center sills give direct support to the seat pedestals.

The two center sills are connected by corrugated stainless steel which stabilizes their flanges and gives a housing for the electrical lines under the car. The floor sheathing is corrugated stainless steel. Cross bearers support the center sills vertically, and the construction at the light body bolster provides the pockets into which the air springs fit.

Corrugated stainless steel is used for the load-carrying exterior side paneling of the body. The nodes are polished for appearance. The corrugations are directly welded to vertical posts at each pier panel and to intermediate stub posts providing extra stiffness. Stamped pier panels combine stiffness and light weight without further reinforcement, and serve to inset the rubber window mountings.

The pier panels are connected to the roof at a joint which provides a strong rail to resist sideswiping loads. The structure is simplified by the absence of a letter board. The corrugated roof is welded directly to Z-shaped carlines.

One-piece, round-cornered frames are used at the side doorways and at the air conditioning equipment openings to reinforce the structure, which would otherwise be weakened because the car's low profile causes the openings to occupy an unusual portion of the car height. The body and truck designs allow a floor height of 39 in. and a platform height of 43 ¼ in. This platform is one step lower than the standard, and a ramp inside at each end of the car brings the passenger down to the coach section floor level. The low platform is possible because a specially shaped diaphragm plate is supported and pivoted directly on the coupler . This allows not only two cars of this design to operate together, but permits the car to be coupled with standard equipment.

The space above the corrugated floor sheathing and below the plywood floor is filled with isocyanate foam generated in place. This supports both floor and sheathing, and provides insulation and sound deadening. End step wells are each single-piece molded plastic units which incorporate light weight, high strength and integral color.

Reinforced plastic exterior components include steps, car skirts and battery boxes. Extensive use was made of same material for interior lining of the car.

These external components and most of the interior finish of the new « Pioneer » are made of laminated, fiberglass-reinforced plastic which has been under development by Budd for some time. This strong, light weight material can be molded to any desired shape, allowing one-piece designs eliminating supporting structure and joints while giving an easily cleaned, better appearing surface. Each

« Pioneer » dimensions.

Length over coupler face (ft-in.)	85-2
Height of coupler (in.)	34 ½
Height of platform (in.)	43 ¼
Height of floor (in.)	39
Height over-all (ft-in.)	11-6
Inside width (ft-in.)	9-5 ¼
Outside width (ft)	10
Truck centers (ft-in.)	59-6
Truck wheel base (ft-in.)	8-6
Cross-overs	No. 7
Radius of curvature (ft)	250

bay (single window span) in the coach section is lined with one panel extending from the heater guard to the nose edge of the luggage rack — including the window trim and lower baggage rack surface. A second panel combines the upper surface of the baggage rack, the ceiling, and half the air duct. The panels are connected between each window with a single extruded aluminium molding. Fiberglass insulation is used behind the panels.

The desired color is built into the panels and no painting is required, thus contributing substantially to lower maintenance costs. The hard wearing surface will resist normal surface scuffing. Should repairs be required, they can be made in place or the entire panel can be replaced. In the washrooms, a single reinforced plastic piece combines the outer wall lining with the hopper and wash basin enclosures and provides for towel disposal, lights, towel dispenser and mirror. Both the hopper and washbasin are formed of fiberglass.

No shades required.

Interior partitions are of micartafaced plywood. The safety glass windows have their upper areas deeply tinted so that no shades are required. They are glazed directly into the openings with rubber mouldings. The 100-gal laminated-plastic water tank is located overhead above the lavatories so that no anti-freeze protection will be required. Vinyl plastic, non-corrosive piping is used which will not burst if it should freeze.

The air duct is covered by unit light panels projecting downward to provide a slot for air distribution. These panels mount a double row of 60-in. fluorescent tubes with starters and wiring. The panels are faced with sheets of silvered « mylar » making high efficiency reflection behind the tubes. The light fixtures are corrugated, translucent polyester plastic strips held in place by vinyl-covered metal bands. A light level of nearly 40 ft candles is provided at the reading plane.

Seats on the « Pioneer III » are fixed, semi-bucket type with heatsealed vinyl-foam cushioned upholstery developed especially for the car by U. S. Rubber. Strength of the single-piece, molded, glass-reinforced, double plastic seat is provided by the shape. It is mounted on an aluminum tube base welded to cast aluminum wall bracket and seat pedestal. The upholstery is easily removed and replaced.

Head-end power for this car can come from a locomotive with auxiliary power plants, or from a power car similarly equipped. A part of a power car could serve as a baggage car. Train lines are for 440-V, 60 cycle, 3-phase A.C. A control line would open a breaker on the power source before the jumpers between cars are separated. Also the control system provides for serial starting of air conditioning equipment. In each coach locker is a dry rectifier for charging the 32-V storage battery which supplies D.C. for incandescent lighting at platforms, passageways and washrooms, and for car emergency lighting.

At the vestibule end of the car there is an enlarged entrance aisle. On one side are luggage shelves and water cooler. The air conditioning equipment and electric lockers are on the opposite side. These passage walls are of fluted, stainless-faced plymetal.

The air conditioning cabinet has the compressor and condenser housed in its

lower part. The condenser and fan are mounted to swing out from an opening in the side of the car for maintenance or replacement. The opening then gives access to the high-speed, sealed, Safety-Carrier compressor and its induction motor, which are track-mounted so they can be brought out for easy exchange. Flexible metallic hoses are extensily used, and the entire compartment is lined with plastic and separated from the car's interior paneling with sound-deadening iso-foam.

Washroom assembly is single-piece reinforced plastic structure with provision for assembly of all parts, piping and wiring before unit is installed in car.

Fresh and recirculated air are separately filtered and mixed in a plenum before passing through the track-mounted evaporator which is installed like the compressor for easy maintenance. Refrigerant piping has been brought to a minimum, increasing efficiency and simplifying maintenance. Air is drawn through the filters and evaporator by a single large blower and delivered through a transition duct to the center-ceiling duct for distribution. Heating is supplied by steam train line, and is distributed to the overhead and floor systems through modified Vapor Unizone controls.

The New York LWE electro-pneumatic, straight air system is used with the Budd-designed variable load attachment previously described. Control of maximum brake cylinder pressures is particularly important in a light weight car where load variations are great. The e-p control gives instant application on all cars of a consist, and is followed up by a straight air application through the pneumatic system. These cars cannot be train lined with conventional equipment having automatic brakes for regular service, although Budd « Pioneers » could be equipped with any style of brakes. The LWE brakes will respond only to an emergency application of automatic equipment.

The car and its components have undergone a lengthy series of laboratory tests, as well as tests in actual service to determine riding qualities, braking efficiency, and noise level. Budd, satisfied that « Pioneer III » more than fills its original assignment as a suburban service unit, is now offering it for all types of railroad passenger applications.

[656 .21 & 656 .25]

Comparative merits of CTC and doubling,

by L. C. MOHINDRA,

Chief Design Engineer, Signal & Telecommunication, Railway Board.

(*Indian Railways*, May-June 1956.)

Claims are made with regard to economy in operating expenditure and increase in traffic capacity of a section achieved by the installation of the Centralised Traffic Control. The author discusses the basis of the above claims and deals with the question whether this system can be installed in India in lieu of doubling, in the background of the requirements of increased traffic capacity that will be needed in the coming years.

Centralised Traffic Control is one of the most modern developments in signal engineering, whereby points and signals at a number of stations on a section can all be operated from a suitably located control office by an operator. It is a highly ingenious method of remote control and works on the selective code principle. Each control and indication code is transmitted in three to eight seconds. The indication of the unit operated is exhibited on the control panel in less than half a minute.

In this system, the railway line is « track circuited » throughout and the positions of the various sections of track (whether occupied or clear), the signals and the points are indicated on a diagram in front of the operator. The points and signals are operated by simple thumb switches so located that the operator can easily set a route and lower signals expeditiously. Relay interlocking is provided at each station and the points and signals are controlled through track circuits.

The trains work on visual signals and the authority to proceed is the lowering of the starter signal, which is possible only when the block section is clear. Where intermediate signals are provided, it is possible to lower the starter signal for a following train movement when the train ahead has passed beyond the intermediate signal.

Cost of installation.

The cost of providing CTC depends upon the size of the station yards, the system of signalling existing, the length of the section, the number of intermediate signals provided between stations, availability of electric power supply at the stations and the type of sleepers in the track.

Taking a section of 100 miles with about 20 stations on the section, 10 of which may be 2-line and the rest 3-line, provided with one intermediate signal between stations in each direction, the cost would be approximately as under :

	Rs.
(i) (*a*) CTC code transmitting apparatus	15 lakhs
(*b*) CTC line wires, including those required for block working between stations (cables) .	20 lakhs
(*c*) Power signalling at 20 stations	45 lakhs
(*d*) Track circuiting between stations including intermediate signals	10 lakhs
(ii) Electric power supply transmission lines	20 lakhs
(iii) Providing wooden sleepers in replacement of steel (net cost)	30* lakhs
Total :	140 lakhs

* Wooden sleepers are in extreme short supply and the cost for imported sleepers will be higher.

The cost of CTC per mile, thus be higher.

If CTC is to be provided on a section where steel sleepers exist and electric power supply transmission lines have to be especially arranged — the transmission being necessary at 11 kV or 3.3 kV — the cost for a 100 miles section would be about Rs. 1.4 crores. Where CTC has to be provided on a section provided with wooden sleepers and power supply may be available already at or near the stations — as is the case in several industrially advanced countries — the cost would be Rs. 90 lakhs (140 lakhs — 50 lakhs) only.

Advantages of CTC.

The main advantages claimed for the installation of Centralised Traffic Control are as under :

(i) Economy in operating staff.
(ii) Increase in the capacity of a section.

By providing CTC it is not necessary to provide pointsmen, assistant station masters, cabinmen or tokenmen at the roadside stations. The staff that may be saved on a section of 100 miles is as under :

(i) A. S. Ms.	(20 × 3) —	60	Approximately
(ii) Pointsmen	(20 × 6) —	120	Approximately
(iii) Tokenmen (on busy sections)	(20 × 3) —	60	Approximately

The savings that may be expected to accrue in Europe or America or other similarly advanced countries, where the wage level is high, (should their method of interlocking on a section be similar to ours) would approximately be as under :

(i) 60 A. S. Ms. at £ 400 per annum	£ 24 000
(ii) 120 Pointsmen at £ 350 per annum	£ 42 000
(iii) 60 Tokenmen at £ 350 per annum	£ 21 000
Total :	£ 87 000 per annum

For consideration of a scheme on the Indian Railways, it may be mentioned that the assistant station masters cannot be reduced, as they are required to perform other duties in addition to block working. The savings that may be expected will, therefore, be as under :

(i) 120 pointsmen at Rs. 97/6/per mensem	Rs. 11 685/-/-	This includes average pay, dearness allowance, leave salary gratuity and P. F.
(ii) 60 tokenmen at Rs. 97/6/per mensem	Rs. 5 843/-/-	
Total	Rs. 17 528/-/-	

Or Rs. 2 10 336 per annum

Even ignoring the savings made by reduction in train runs, on a capital investment of £ 1 million in Europe or America, there would be a reduction of £ 87 000, amounting to a return of 8.7 %. In India, on the other hand, on a capital expenditure of Rs. 1.4 crores, the annual savings would be about Rs. 2 16 336, which amounts to a return of 1.5 % only.

Increase in line capacity.

By the provision of CTC, trains on a section can be run expeditiously and capacity can be increased due to the following factors :

a) *Trains work on visual signals :* The time at present spent in obtaining and delivering tokens, when trains have to cross, is saved;

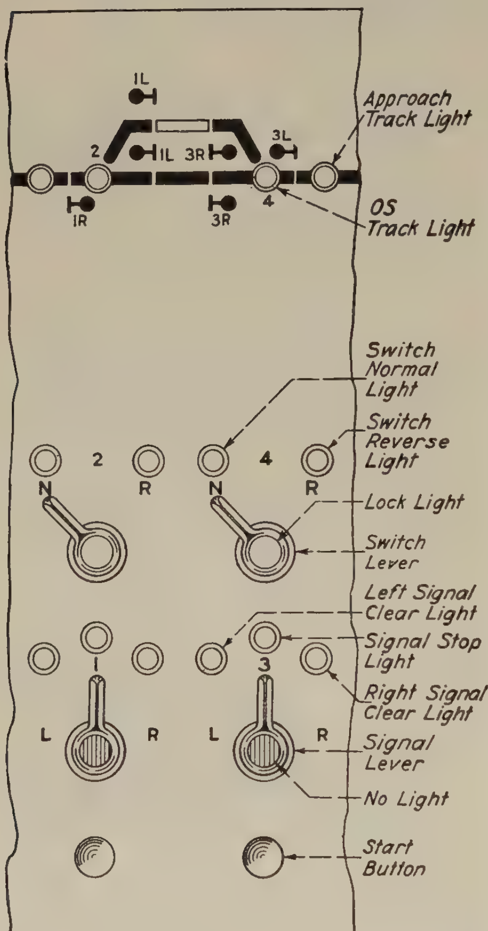
b) *Power operation of points and signals :* Delays due to manual operation of points and signals, particularly when trains have to cross, are reduced;

c) *Following trains :* A train can be despatched following another, before it has reached the Block station ahead. This saves time when dealing with rush of traffic in the same direction;

d) *Unmanned crossing stations :* Crossing stations, which need not be manned,

can be provided to break long block sections;

e) Improved crossing arrangements : The operator has up-to-the-minute position of the various trains, points and



A section of a panel at the CTC control office showing a station with relevant controls, thumb switches and indications.

signals from the electrical indications on his diagram. The train crossings and the train movements generally can, therefore, be planned and expedited in the most appropriate manner.

The extent of increase in capacity effected by the provision of CTC would depend upon the system of signalling and block working existing on a section prior to the provision of CTC. The extent of percentage increase in capacity would, therefore, vary depending upon the systems existing.

How much increase in capacity?

Where CTC is to be provided on a section, which is non-interlocked or where the existing system of signalling entails loss of time in crossing arrangements, or where trains work on « train orders », « paper line clear » or « token », or where there are no facilities of following trains and the distance between block stations is long, the percentage increase in capacity would be quite considerable.

On the other hand, if CTC was proposed for a section where interlocking arrangements already permit of unrestricted speeds through the station yards and the method of interlocking is « direct » and involves no delay in their operation and where additional crossing stations are being already provided to break long block sections. and a traffic controller on the section already exists, who keeps in touch with the position of various trains on a section all the time (keeping a graph of the train movement in front of him) and tokenless working is provided, the time saved would be limited. The percentage increase in capacity would then be mainly due to the time saved as a result of only one operator controlling the entire section and would consequently, be much less.

Experience in New Zealand.

In New Zealand, the increase in capacity for providing CTC could be claimed to be 50 to 60 % and this claim can be justified, taking into account that they have had the following methods of working on certain sections, which are basic-

ally slow and involve loss of time for train crossing on the single lines. This is how these systems work.

(i) On a number of single line sections, they have installed automatic signalling of a special type. It is designed primarily to work trains on a section without providing any operating official at the road-side stations. Trains work on automatic signals between stations and through the station yards, but when trains have to cross, the points have to be set by the train crew themselves. The points are not locked by any interlocking apparatus, but are clamped and padlocked. The key remains in the custody of every driver running on the section.

The arrangement is that when two trains have to cross, the first of the two trains stops at the facing points. The fireman gets down with the key of the padlock, unlocks the points and sets them for the loop line — the common rule being that the first of the two trains is to be received on the loop. After allowing the train to be admitted on the loop line, the fireman resets the points for the main line and after padlocking them returns to his train at the station. After the passage of the opposing train, the fireman of the train (standing on the loop) sets the trailing points in its favour and the train is allowed to go past the points leaving the fireman behind, and stops clear of the points. As soon as the train has cleared the points, the fireman resets the points for the main line and proceeds to the engine, after which the train continues its journey.

(ii) The system of block working is the « train order » system. In this system, trains work normally to a time-table. This suffers from a drawback that if a train loses time, the normal train crossing arrangements are upset and a prescribed procedure has to be followed, which involves considerable loss of time.

Increase in capacity by providing CTC on such sections which are equipped with signalling permitting unrestricted speeds, without partial doubling or additional crossing stations, would not be more than 15 to 20 %.

Number of trains run daily.

The number of trains which can be run on a single line depends upon the distance between stations, mode of traction, the speeds of trains, apart from the system of signalling — whether CTC or manual-operated signalling. On railways where the distance between block stations is short, Diesel or electric traction is provided and speeds are as high as 90 to 100 miles per hour for mail trains and 60 miles per hour for goods trains, the number of trains run on a section may be as many as 50 to 60 daily.

On railways where the distance between stations is long and steam traction is employed, which suffers from lower speeds, lower acceleration and deceleration, and the time loss in taking water and maintaining correct steam pressure, the number of trains that can be run daily would be much less.

CTC or doubling?

The installation cost of CTC is 1.4 lakhs per mile, whereas the cost of providing an additional line required for doubling would be about Rs. 4 to 5 lakhs. Moreover, on account of the savings involved due to the difference in the annual interest on capital expenditure, maintenance and operating expenses for doubling vis-a-vis CTC, the capital cost of CTC would pay for itself within 5 to 10 years, if thereby doubling could be deferred.

CTC, therefore, is an attractive proposition where the requirements of added capacity can be met for a number of years. But where doubling has to be provided earlier (wherein the section can be worked with manually-operated signalling) which would provide nearly 120 % additional capacity and would meet additional requirements of the country for

many years to come, CTC equipment would not be necessary and there would be considerable infructuous expenditure.

CTC in Indian conditions.

The following factors also deserve consideration :

(*i*) *Upsetting of normal working during failures :* If CTC is provided on a busy section, the failures of the equipment are likely to upset the normal working;

(*ii*) *Import of material :* CTC equipment is of a highly specialised technique and will have mostly to be imported, whereas material for doubling may be available mostly indigenously. Sufficient wooden sleepers are also not available in the country;

(*iii*) *Dislocation in single line working :* Doubling avoids dislocation of traffic in case of one line being disturbed;

(*iv*) *Reduction of employment :* Doubling will provide employment to labour during construction and also for maintenance and operation, whereas provision of CTC will render a certain amount of staff surplus, which is against the present day economy of the country.

On sections where the required stations are already fully interested and increase in capacity required is 15 to 20 % which in the course of the next 10 to 15 years may go up to 25 to 35 % (this includes capacity realised by additional crossing stations), provision of CTC could be considered. Its provision on one or two sections would also enable the Indian Railways to gain practical experience.

However, on sections where the increase in capacity required is more than 25 % and the requirement is likely to grow in the coming years, doubling appears to be the correct answer and CTC is not expected to deliver the goods.

NEW BOOKS AND PUBLICATIONS.

[**385** .02]

DIRECTORY OF RAILWAY OFFICIALS AND YEAR BOOK, 1956-1957. — London : Tothill Press Limited, 33, Tothill Street, Westminster. S.W.1. — One volume of 526 pages (8 1/2 × 5 1/2 inches). Price : 40 s. net.

The Directory of Railway Officials and Year Book, 1956-1957, reaches with the present volume its 62nd year of publication.

The first edition was compiled from official sources in 1895. The present edition of 526 pages covers the text including a general index and the personal index to railway officials, a noteworthy feature of the volume.

This edition should prove as valuable as its predecessors. There has been markedly changes in the layout and general arrangement in this year's edition.

The outstanding alteration is the arrangement of all countries of the world (other than Great Britain and Ireland) in alphabetical order, irrespective of their geographical or political grouping. Moreover, the railways in any one country are brought together, whether they are large or small. This should facilitate ready reference.

More details which have become available concerning such countries as Argentina, Czechoslovakia, India, Jugoslavia and the Union of Soviet Socialist Republics have been included.

General revision of the statistical sections, as the result of world-wide enquiries, has permitted substantial adjustment of the statistical information about the railways of many countries.

This very interesting publication will be greatly appreciated by all those concerned with railway matters.

Ist. International Congress of Funicular Transport.

(1° Congresso Internazionale dei Trasporti a Fune)

Rome, May 1957.

The First International Congress of Funicular Transport will be held in Rome, during the first fortnight of May 1957.

This Congress is organized by the Italian Ministry of Transport.

All firms and undertakings and those interested in funicular problems (in particular, telphers, aerial ropeways, etc.), to whichever country they belong, may participate to this Congress. The participation of University professors, specialits on these questions, will be also welcome.

The agenda of the Congress includes the study of general subjects as well as questions dealing with the aerial ropeways, equipment of the lines and stations, fittings and the working.

The papers submitted by the participants must reach the Congress Secretariat before the 31st December 1956.

The closing date for the registration of participants is the 28th February 1957.

All requests for participation or information must be sent to the following address : « Segreteria I Congresso Internazionale dei Trasporti a Fune, Ministero dei Trasporti, Ispettorato Generale della Motorizzazione Civile e dei Trasporti in Concessione, Roma. »

A. U.

ANALYTICAL TABLE OF ARTICLES

ARRANGED ACCORDING TO THE DECIMAL CLASSIFICATION

(1956)

M. WEISSENBRUCH & Co. Ltd.
Printer to the King

(Manag. Dir.: P. de Weissenbruch,

Bulletin of the International Railway Congress Association

CONTENTS OF THE NUMBER FOR JULY 1956

Bulletin of the International Railway Congress Association

CONTENTS OF THE NUMBER FOR AUGUST 1956

Bulletin of the International Railway Congress Association

CONTENTS OF THE NUMBER FOR SEPTEMBER 1956

Bulletin of the International Railway Congress Association

CONTENTS OF THE NUMBER FOR OCTOBER 1956.

Bulletin of the International Railway Congress Association

CONTENTS OF THE NUMBER FOR NOVEMBER 1956.

Bulletin of the International Railway Congress Association

CONTENTS OF THE NUMBER FOR DECEMBER 1956.

MONTHLY BIBLIOGRAPHY OF RAILWAYS (1)

PUBLISHED UNDER THE SUPERVISION OF

P. GHILAIN,

General Secretary of the Permanent Commission of the International Railway Congress Association.

(AUGUST 1956)

[**016.** 385 (02]

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Nouvelle conception de la résistance des matériaux. rsion, effort tranchant. Synthèse de la mécanique des ls et des solides. Vérifications expérimentales. Applican au béton armé et au béton précontraint.
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